ADVERTISING PAGES REMOVED

ROADS AND STREETS

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Planing Puddle Macadam on U. S. Route 50

Testing for Irregularities with "Graderater" Before Final Seal Coat

Completed Pavement on U. S. Route 50

Methods of Constructing Bituminous Macadam Surfaces of Extra Smoothness

Practice in West Virginia, Together with a Description of the Roughness Testing Equipment and the Construction Methods Used on a 10-Mile Section Built in 1928

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ALL too frequently macadam roads have been built as if they were to be temporary surfaces; a wrong attitude to begin with. Any improvement to a state highway should be with the idea that stage construction is possible, and that as traffic increases, the surface may be strengthened and widened, utilizing all previous work. This means that even for low cost roads, careful attention should be given to alignment and grade, and with drainage structures properly placed to take care of future changes with minimum cost. There is no reason to slight work just because funds are limited; on the contrary, the best engineering talent should be employed to obtain maximum results from these limited expenditures.

As in every other phase of human endeavor, there is usually a reason for any particular set of conditions, and in the construction of macadam types, poor results come about largely because of too little insistence in the observance of fundamental principles, and the hope (if it may be so termed) that in some way a good surface would finally happen. It is all very well for a group of executives to get together and write a set of specifications for methods and materials. It is quite another, to go back home and build an organization of engineers and inspectors to carry them into practice, especially with the "feast or famine" condition that exists in public work. And yet it is upon the inspector that success or failure largely depends, and he must be sold on the need for doing work as planned, and imbued with a desire to obtain quality results; never satisfied with anything less.

Early Macadam Roads.—Early macadam roads were built by laying either crushed or napped stone upon road beds which had been stabilized under horse-drawn traffic. The layer of stone was filled with screenings, and then water bound and rolled. Under iron tired traffic there was gradual wear so that additional dust was continually being worked into the voids, and over a period of years these surfaces became very firm and fairly smooth. Any serious variations were repaired by adding fine stone and additional screenings, and for the slow moving traffic, no particular need was felt for extremely even surfaces.

With the advent of the automobile, such surfaces deteriorated very rapidly, due to tire suction and consequent loss of filler. The first experiments with surface treatment brought widely varying results, but in general they were satisfactory, and adequate for motor vehicle speeds of not over 25 miles per hour. With the further growth of traffic, rapid extensions of roads were made. The old methods of construction were still followed, and on new road beds, much settlement occurred, until in many instances macadam types

obtained a bad name because of roughness. No particular requirement was made as to checking sub-grade and base, it being generally thought that all irregularities could be taken out when the top-course was placed. It is needless to add that experience soon showed that such conclusions were erroneous, and resulting from the experience gained over the intervening years, state highway specifications have been written, which now take into account the absolute necessity of giving as close attention to every step in the construction of a macadam surface, as for the most costly pavement.

Present Methods in West Virginia.— West Virginia specifications of 1929 call for sub-grade to be prepared in accordance with profile, grade, and cross-section, with variations not to exceed ¼ in. in 10 ft. of length. Before placing any stone, the sub-grade is to be thoroughly rolled, all weak or soft places to be stabilized with solid materials, and the entire area to be checked prior to placing any stone. Specifications for the stone call for a product of uniform quality, proper grading, and size. Extreme care is taken in placing base-course to see that uniform depth is obtained, and the surface is closely checked. Every care is then taken to see that the base-course is thoroughly filled with stone screenings and dust, in order that all voids shall be full and no movement in the base-course possible. It is preferable that new base-course shall be constructed one year, and top-course laid the year following. There is a decided tendency to change the specifications and methods of construction so as to follow this plan.

Where the basecourse is laid one year and then opened to traffic through the following winter, the surface should be treated with asphalt in two applications, the first consisting of ¼ gal. asphalt primer coat, which is readily absorbed and requires no cover, and the second application of ¼ gal. cold liquid asphalt applied several weeks afterward, and covered with approximately 20 lb. of chips. In no case should base-course be laid upon road beds graded the same year (unless absolutely necessary); as some settlement is bound to occur with resulting distortion of the surface.

While napped stone base of fair quality has been laid, yet in order to obtain really smooth riding surfaces this type should be discouraged and crushed stone used instead. As a further step in obtaining smooth surfaces, this crushed stone base should be built up in layers, each not to exceed 4 in. compacted depth. Specifying such a maximum depth insures thorough filling, and consequent less likelihood to move under traffic. To obtain results which will comply with these specifications throughout, requires most rigid inspection. The old methods of laying macadam pavement had become so well established that very few contractors appreciate this need for refinement, and failing to see the value of checking so closely, there is required constant supervision on the part of the inspector to see that proper results are obtained.

Equipment for Testing Smoothness. — Somebody has said that "Genius consists of an infinite capacity for taking pains," and certainly the construc-

First Application of Chips

tion of macadam pavements of extra smoothness depends entirely upon such attention. To insure high quality, several additional types of equipment have been devised, and successfully used during the past season. The old time straight edge, of course, together with the template for obtaining proper cross-section, are used constantly on both sub-grade, base-course, and top. After surface treatment of the base-course, and prior to placing the top, an additional instrument has been tried, known as the "Grade-Rater." This is a wooden frame, approximately 10 ft. in length, with a small wheel at each end, and in the center a metal pointer which drags on the surface of the pavement, and indicates any variation (in fractions of an inch) on a scale at the top. The machine is operated with a pair of light plow handles, and the scale is readily visible to the operator. The method is to push the machine longitudinally with the road, and whenever the scale indicator shows a variation beyond the specification tolerance, a chalk mark is made indicating the high or low area. The "Grade-Rater" is run down and back twice on either side of the center so as to cover every 4 ft. interval of width. All areas which vary from the true surface are patched before placing the top-course. In making these patches, the greatest care should be taken to use a minimum amount of asphalt, in order that no change in texture may occur. It is essential that the base-course conform exactly to the desired cross-section and profile, if the final surface is to remain smooth.

The same care is taken in placing top-course; first, to obtain a uniform material with the densest possible grading, and then to follow the same procedure of checking for irregularities before the final seal coat. One of the most common faults in construction is the tendency to use too much bituminous material. If the surface appears to be somewhat irregular in color, dry, and with even a number of small pittings, there is nothing to worry about, as it can be easily corrected with the final seal coat. On the other hand, a surface which has a very black, totally flushed appearance, is quite apt to be too rich, and with the application of the seal coat corrugations result. Prior to the seal coat, the "Grade-Rater" is again run over the surface to check all variations from standard, and all low places are again patched, using the minimum possible amount of bitumen. It is during this process of checking, adjusting, and patching, that the greatest difficulty usually occurs with the contractor, and it is a time when the inspector needs to exercise all of his tact and patience, and yet at the same time to be persistent and insistent that his instructions are carried out.

It is desirable that several weeks to several months elapse before the seal coat is applied. This gives an opportunity for settlement and compaction of the top-course, and for all spongy, loose areas, to whip out under traffic, thus leaving a solid surface on which to apply the final application of bituminous material. This final application is ¼ to ⅜ gal. cold liquid asphalt, but which is heated to about 100° F. A sufficient amount of ¾ in. chips is applied to take up all surplus bitumen, and here again a new machine has been employed with satisfactory results. It is difficult (even with experienced operators) to apply chips from stock piles in an absolutely uniform manner. The several chip spreaders (which have been used) also produce results that vary considerably between the beginning and the ending of the load. To overcome this difficulty, the following instrument has been devised. It consists of a triangular frame made of steel, supported on wheels at each corner, with a cross member to which is attached a 10 ft. length of wire brooms. This cross member may be moved vertically to obtain any desired pressure of the brooms on the surface. It is operated immediately after the application of chips, producing a uniform distribution over the surface, thus overcoming any tendency to bunching. While at first thought it would appear to be of minor importance, yet it contributes that extra refinement which results in a perfect surface.

Construction Methods on U. S. Route 50.—To substantiate the conclusions set forth above, an experiment in construction was made during the past summer

on U. S. route 50 crossing the Allegheny Mountains. The section is 10 miles in length, the roadway having been previously graded and all drainage structures installed during 1923-24. Through the intervening years, constant maintenance has been carried on, so as to produce an entirely stable, graded earth road. Contracts were let for this 10 mile section, divided in two 5 mile parts, one being for crushed stone base. Work proceeded simultaneously on the two sections, and they were completed nearly at the same time. The grade was so laid as to require trenching from one end of the job to the other, thus putting the sub-grade in thoroughly compacted material; maintaining the full roadway width, and in addition providing a surplus of berm material so that no disfiguring robbing of the slopes was necessary. The precautions set forth above, such as checking sub-grade, stabilizing weak spots, placing the base-course with carefully graded, uniform material, insistence upon thorough filling and rolling, checking with straight edge and template to the specification tolerance, were all carried out. Just prior to the completion of the base, a single contract was let for the full 10 mile length of top-course, the type being "puddle macadam," 3 in. compacted thickness, 18-ft. in width, and with a 2 in. crown.

This surface was laid under traffic, full width, with only a temporary barricade during the few minutes required to pour the first application of one gallon per square yard. The method of constructing "puddle macadam" has been previously described in a paper before the Highway Research Board, December, 1927. An experiment was made this summer, however, using asphalt primer coat for the initial application. It had been thought previously that insufficient penetration would be obtained using this material, but on the contrary a penetration of 1½ in. was had within two hours after application. Practically no cover coat was required, other than just enough to prevent picking up of the surface. Rolling was delayed for about an hour after application, and then made once over to obtain initial compaction. Rolling continued at intervals of several days thereafter, as the asphalt residue hardened, to keep the surface in shape. The results were very satisfactory, and this material will be specified for future work. The pavement was laid at the rate of about 1500 lin. ft. per day, and all of the precautions for testing the surface were carried out as above noted, the inspector being an unusually persistent individual, and contrary to the recommendation of one of our great industrial leaders, a man of about 60 years of age. He was on the job at 7:00 A. M., and did not leave until after the contractor at night, a quality not always found with some of our younger college graduates. Traffic used this surface for several months prior to the seal coat, and while very little asphalt had flushed the surface, and a certain amount of shallow pitting occurred, this was not at all harmful. The final seal coat consisted of ⅜ gal. cold liquid asphalt, heated to maximum fluid condition, covered with approximately 20 lb. of chips, and dragged with the steel broom as outlined above.

Shortly after this contract was finished, the remaining gap on U. S. 50 in Maryland was also completed, and immediately thereafter a large increase in traffic took place, so that an excellent opportunity has been had during the past two months to determine the riding qualities of the macadam section after being subjected to concentrated high speed traffic.

Test of Surface Smoothness.—For the past year our roads have been checked with a roughometer every two or three months to determine their relative smoothness and whether or not they are changing in their riding qualities. Previously built macadam with good smooth riding surfaces have had an index of 100 to 150. Good riding concrete built in previous years has run between 75 and 125. These are pavements that two or three years ago were considered of good quality in smoothness and easy riding. The index for the ten miles constructed with the methods outlined above is between 50 and 60 for the crushed stone base section, and from 55 to 65 for the knapped stone base. Even with every precaution, it is not possible to obtain the same smoothness with knapped stone, and it is probable that any deterioration in riding qualities will be more marked for the knapped stone than for the other. The index is arrived at from the amount of spring deflection over a mile of road at 25 miles per hour, so that the lower the index, the smoother the surface. Hundreds of miles of road have been checked with this instrument under all conditions of weather and temperature, so that good calibration is had, and while the results are not absolute, yet their comparative values are certain. Car speeds on this 10-mile stretch have run as high as 60 to 80 miles per hour on tangents, and while such speeds are by no means encouraged, yet the public derives a certain satisfaction in having pavements on which they can drive fast if desired. The many compliments received on this road further proves that the public is not so much interested in the type of road, as they are in its smooth riding characteristics, and that if a state desires to continue the use of the so called cheaper types, then all they have to do is to use the same care and preparation as for the more expensive surfaces. The cost of good inspection is much less than poor inspection, for the saving is immediately reflected during the subsequent years, in lower maintenance charges, and the satisfaction derived from the excellence of the road.

Rolling and Filling Top Course

The same principles apply to the construction of gravel, "retread," or even asphalt treated shales. It pays to take pains with the smallest details. If by following these methods, excellent durable surfaces can be obtained at costs from $5,000 to $20,000 per mile, and then maintained thereafter at an annual expense which is less than the difference of interest charges on these types and the expensive pavements, assuredly there will be much approbation from the public because of the much larger mileage from the same expenditure of funds. I repeat; the public does not care what the road is made of, but it does demand (and properly so) that those roads shall be smooth, and safe.

Acknowledgment.—The foregoing is a paper presented at the 8th Annual Asphalt Paving Conference.

Map Collections in Washington

The Board of Surveys and Maps of the Federal Government has compiled a list and brief description of the map collections and map-selling agencies in the District of Columbia.

These data were compiled from replies to a questionnaire sent to each of the bureaus asking for the information in brief form, which has been used in describing the various agencies. There are about 40 bureaus and independent establishments that have collections of maps, nearly all of which are available for consultation by the general public in connection with research work and investigations.

Copies of this publication can be furnished free of charge to those interested as long as the limited edition is available by application to the Board of Surveys and Maps, Room 6204, Interior Department Bldg., Washington, D. C.

Weather Conditions, Working Days, Bonus and Penalty Requirements

Requirements of the 48 State Highway Departments on the Penalty and Bonus Clause, Together with Data on Weather Conditions in Planning Work

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THE item of "working days," bonus and penalty in connection with all construction contracts have been from the first problems which have proven most troublesome to engineers and contractors.

Working Days

The practice of the contractor bidding the number of working days and this item receiving a monetary consideration in the award is rapidly being discontinued, and is being replaced by a date set by the engineer for the completion of the work.

In the 48 states only 4 require or permit the contractor to bid the number of working days. In the other 44 states the date of completion is set by the state highway department. This fact should influence contractors to make a careful check of the average weather conditions for the immediate territory in which the project is located, in order that he may intelligently decide as to the equipment which he will place on the work and his method of procedure.

Approximately two years ago the American Road Builders' Association began the collection and tabulation of data on average weather conditions, working days, and bonus and penalty clauses, throughout the United States. These data have been secured largely from the 1929 report on equipment of W. A. Van Duzer, Assistant Chief Engineer, Pennsylvania Department of Highways, from the United States Weather Bureau and from the 48 State Highway Departments. These organizations have made possible the detail in which the following paper, which was presented at the 1930 convention of the American Road Builders' Association, was prepared.

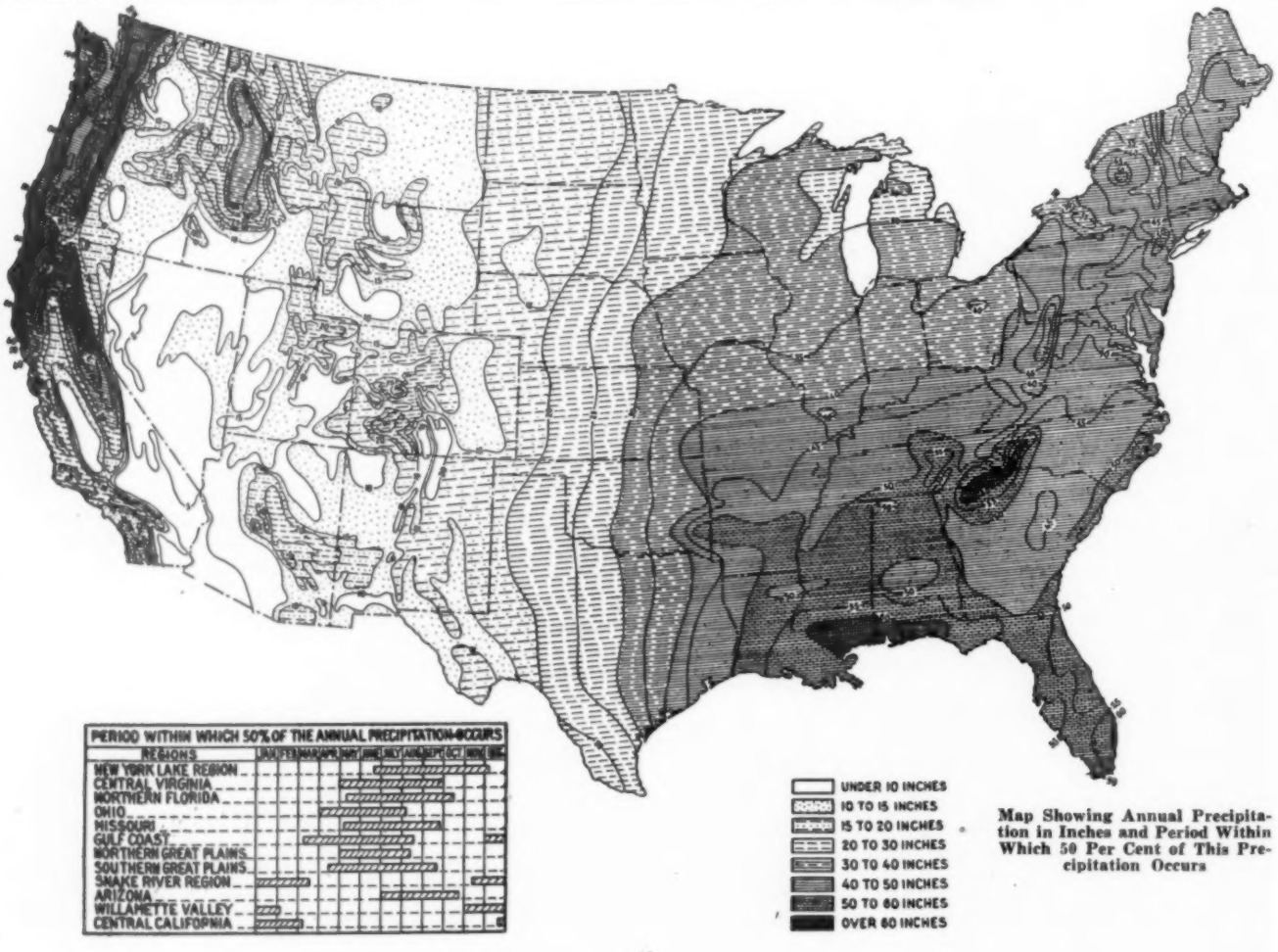
To aid the contractor in this respect we have carefully compiled Table I showing the following information for the various sections of each state:

Working Days for Grading.
Working Days for Paving.
Mean Annual Precipitation.
Mean High Temperature.
Mean Low Temperature.
Mean Frost Date—Spring.
Mean Frost Date—Fall.

Conclusions Regarding Weather Conditions. — These data show average weather conditions which when applied give the following conclusions:

Grading—Working days vary from 140 to 300.

Paving—Working days vary from 100 to 300.



Map Showing Annual Precipitation in Inches and Period Within Which 50 Per Cent of This Precipitation Occurs

Table I—Working Days and Climatic Conditions in the Several States for Highway Construction Average for Entire State, Number of Working Days Per Year, Exclusive of Sundays, Holidays and Bad Weather

State	Portion	*Working Days		Mean Annual Precipitation	Temperature		Mean Frost Date	
		Grading	Paving	Inches	Mean High	Mean Low	Spring	Fall
Ala	N. & W.			49.00	105	— 9	Apr. 25	Oct. 15
	E. C. & S.	240	240-300	55.32	105	0	Apr. 20	Oct. 15
Ariz.	Southern			10.95	113	+ 9	Apr. 15	Oct. 25
	Northern	200-300	200-300	16.12	107	—10	June 1	Sept. 20
Ark.	Southern			46.22	108	— 9	Mar. 20	Nov. 10
	Northern	300	300	47.25	109	—17	Apr. 15	Oct. 15
Cal.	Southern			14.10	110	+15	Apr. 10	Nov. 1
	Central			18.85	111	+17	Apr. 20	Oct. 15
	N. Eastern			34.81	108	+ 4	June 1	Oct. 5
	N. Western	155-300	120-300	40.22	107	+14	May 25	Oct. 15
Colo.	S. Eastern			17.30	99	—30	June 15	Sept. 15
	N. Eastern			16.88	99	—32	June 25	Sept. 15
	Western	No Data	No Data	17.03	94	—33	July 1	Sept. 5
Conn.		180-210	125-155	42.01	99	—24	June 5	Sept. 10
Chesapeake Bay Region				42.82	104	—11	May 5	Oct. 25
Delaware	(See Chesapeake Bay Region)			(Grading 220 Days)			(Paving 160 Days)	
Fla.	Northern			53.60	103	+10	Apr. 15	Nov. 1
	Southern	240	240-up	41.43	99	+22	Mar. 10	Dec. 1
Ga.	Western			52.48	104	— 4	Apr. 25	Oct. 20
	Cent. & East.	300	300	49.44	107	— 2	Apr. 20	Oct. 15
Ida.	Northern			23.22	103	—24	June 25	Sept. 1
	Southern	120-200	80-120	14.56	105	—29	July 1	Sept. 1
Ill.	Northern			33.12	107	—27	June 1	Sept. 15
	Central			36.04	106	—25	May 15	Sept. 20
	Southern	180-240	125-135	41.41	109	—20	May 10	Sept. 25
Ind.	Northern			36.07	105	—23	May 25	Sept. 15
	Southern	160-175	120-140	42.52	107	—22	May 15	Sept. 20
Iowa	Western			32.39	108	—36	May 20	Sept. 15
	Central			32.39	108	—33	May 20	Sept. 15
	Eastern	175	125	32.39	107	—31	May 25	Oct. 5
Kan.	All	200	140	28.50	111	—27	Apr. 25	Oct. 20
Ken.	Eastern			46.87	104	—20	May 10	Sept. 25
	Western	175	100	45.40	106	—21	May 10	Sept. 25
La.	Southern			56.37	106	+ 7	Mar. 10	Nov. 15
	Northern	225	225	49.32	107	— 2	Apr. 20	Oct. 20
Maine	All	140	110	40.66	98	—29	June 15	Sept. 10
Md.	W. & Cent. (See Potomac River Basin)							
	Eastern	180-240	140	(See Chesa. Bay Region)				
Mass.		225	150	42.01	99	—24	June 5	Sept. 10
Mich.	Upper Penin.			30.00	99	—37	June 15	Sept. 1
	Western Lower			31.00	102	—29	June 5	Sept. 10
	E. Lower	180	130	32.00	103	—29	June 15	Sept. 10
Minn.	S. Western			25.31	104	—38	May 15	Sept. 25
	S. Eastern			28.65	105	—40	May 15	Oct. 1
	Northern	150	100	24.98	102	—48	June 15	Sept. 1
Miss.	Northern			49.30	104	— 6	Apr. 25	Oct. 10
	Southern	240	160	55.82	104	+ 2	Apr. 20	Oct. 20
Mo.	S. Western			40.00	109	—27	May 15	Sept. 20
	S. Eastern			44.98	109	—24	May 15	Sept. 25
	Northern	No Data	No Data	36.67	109	—26	May 15	Sept. 25
Mont.	S. Eastern			14.35	106	—45	June 10	Sept. 1
	S. Western			15.05	101	—43	June 20	Aug. 20
	Western			17.82	102	—33	June 20	Aug. 25
	N. Central			16.00	102	—46	June 20	Aug. 25
	N. Eastern	No Data	100-120	14.27	108	—52	June 15	Aug. 25
Neb.	N. Western			19.75	106	—35	June 5	Sept. 10
	N. Eastern			27.75	109	—36	May 25	Sept. 15
	Southern	250	225	25.00	111	—33	May 25	Sept. 15
Nev.	All	240-300	150-175	7.21	106	—21	June 25	Sept. 1
N. H.		140	100	42.01	99	—24	June 5	Sept. 10
N. J.	S., I. & Coast			47.68	103	—10	May 20	Sept. 25
	Northern	190	140	47.44	104	—18	May 20	Sept. 20
N. M.	W. & S.			13.43	113	—18	May 7	Oct. 20
	N. Western			14.09	100	—22	June 15	Sept. 25
	N. Eastern	No Data	No Data	17.87	102	—20	May 25	Oct. 1
N. Y.	Western			35.20	99	—23	June 10	Sept. 10
	Central			39.09	98	—30	June 10	Sept. 10
	S. Central			38.76	99	—30	June 15	Sept. 10
	Eastern	160	150	41.68	100	—24	May 25	Sept. 15
N. C.	E. & W.			51.66	98	—16	May 20	Sept. 25
	W. Central			51.46	102	— 7	May 5	Oct. 5
	C. & S. E.			48.06	104	— 4	May 5	Oct. 10
	N. Eastern	200	200	48.23	102	— 2	Apr. 25	Oct. 15
N. D.	Western			15.69	105	—47	June 15	Aug. 25
	Eastern	150	180	19.26	105	—46	June 15	Aug. 20
Ohio	Northern			36.74	104	—23	June 1	Sept. 15
	S. Western			39.36	105	—24	May 20	Sept. 25
	S. Central			38.68	105	—26	May 25	Sept. 20
	S. Eastern	No Data	No Data	39.38	104	—25	May 25	Sept. 20
Okla.	Eastern			38.75	110	—14	Apr. 25	Oct. 10
	Western	225-240	225-240	30.00	112	—14	May 1	Oct. 1
Ore.	Western			51.44	101	— 5	June 1	Sept. 25
	Eastern	No Data	No Data	14.00	104	—24	June 20	Sept. 10
Pa.	Western			41.41	103	—14	June 5	Sept. 15
	Central			40 08	103	—24	June 5	Sept. 15
	Eastern	190	120-140	46.09	103	—18	May 20	Sept. 20
Potomac	River Basin			39.37	104	—19	May 15	Oct. 5
R. I.		190-200	140-150	42.01	99	—24	June 5	Sept. 10
S. C.	Western			48.75	105	— 1	Apr. 20	Oct. 15
	Eastern	210-240	180-240	47.16	105	+ 2	Apr. 15	Oct. 20
S. D.	Western			18.50	108	—40	June 1	Sept. 5
	Eastern	130-165	110-140	22.30	107	—42	June 25	Sept. 1
Tenn.	Middle West			50.83	104	—18	May 15	Oct. 1
	Eastern	190	175	51.66	98	—16	May 20	Sept. 25
Texas	N. Western			24.50	109	—10	May 10	Oct. 15
	Central			26.50	110	— 4	Apr. 25	Oct. 20
	Eastern	240-300	180-240	40.00	111	— 5	Apr. 25	Oct. 20
	Southern			31.88	107	+ 8	Apr. 5	Oct. 25
	W. & S.			13.43	113	—18	May 7	Oct. 20
Utah	Eastern			11.13	104	—25	June 20	Sept. 10
	Western	170-180	170-180	13.93	103	—23	June 25	Sept. 10
Va.	South & S. W.			43.60	100	—19	May 20	Sept. 25
	S. & E.			42.87	102	— 4	Apr 25	Oct. 10
	Central	180-210	150-180	41.60	104	—13	May 15	Oct. 5
Vt.		155	115	42 01	99	—24	June 5	Sept. 10
Wash.	Western			49.14	97	0	May 25	Sept. 25
	Eastern	180-300	150-240	15.48	107	—24	June 25	Sept. 15
W Va.	Northern			45.84	103	—26	May 30	Sept. 25
	S. & S. W.	No Data	120-180	43.60	100	—19	May 20	Sept. 25
Wis	N. Western			30.00	101	—43	June 10	Sept 5
	Central			32.00	102	—41	June 10	Sept. 5
	Eastern	140-150	110	31.40	106	—32	June 1	Sept. 20
Wy	Western			16.04	94	—46	July 15	Aug. 10
	S. Eastern			14.28	98	—38	June 20	Aug. 25
	N. Eastern	200	140-160	13.03	101	—38	June 20	Aug. 20

Precipitation ranges from 7.21 in. to 55.82 in.

Maximum average high temperature 113° in Arizona and New Mexico.

Minimum average low temperature 52° below zero in Montana.

In Florida the average last date of frost in the spring is March 10th and the first in the fall Dec. 1st.

In Wyoming the last frost in the spring averages July 15th and the first frost in the fall averages Aug. 10th.

Penalty and Bonus

A recent canvass of the state highway departments of the 48 states discloses that:

All of the states inflict upon the contractor a penalty for failure to complete work on time. This penalty is variable in form but the one commonly used is the practice of charging the contractor with the additional cost of engineering required by his failure to complete the work within the time specified. Other forms of penalty include a specified sum incorporated in the contract as liquidated damages to the state and immediate forfeiture of contract. Of the 48 states nine specify a bonus for the completion of work ahead of time. The bonus is usually set up along with the penalty on a basis of a definite monetary consideration per day. In other words, on a contract of a definite total monetary value the penalty for failure to complete on time is a stated amount for each day overtime and a bonus of equal amount is given for each day that the contract is completed ahead of the stated time.

Table II shows requirements of each state for bonus and penalty provisions.

The Connecticut Plan.—The method of penalty and bonus used successfully by the state highway department of Connecticut is worthy of particular mention. This method is to specify that liquidating damages at a certain daily rate will be charged for each day that the contract is in operation. This daily time charge is deducted from each monthly estimate, as the work progresses. No specified number of days is set by the department, the contractor estimates the days it will take him to complete the work and adds to his unit prices an amount sufficient to cover the total time charge for the number of days that he figures it will take him to do the work. Of course in this case he is gaining when the work is completed in a less number of days than he estimated, while in cases where a greater number of days are taken to complete the work, there is a direct loss to the contractor. This method is also used to some extent in one or two other states.

Use of Bonus Provision Increasing.—It is a known fact that, under the law, a penalty clause for overrun in time cannot be enforced unless the contract carries a compensating clause with a bonus for completion of work ahead of the specified time. However, in many of the states penalties are inflicted on the contractor which, if the contractor resorted to law, perhaps could not be collected. This may be explained by the fact that the co..tractor considers his objection to the penalty a poor economic measure in view of the possibility of impairing his good standing with the department. The unfairness of the penalty clause without the compensating bonus is being more rapidly realized by state highway departments each season, with the result that nine states are now incorporating in the contracts the bonus provision.

The exceptional wide ranges of weather conditions as noted and the variable requirements of the state highway departments in connection with working days, penalty and bonus are most certainly indicative of the necessity of these items receiving the most careful consideration from all bidders.

The policy of the Association is to make practical applications of such data and to form conclusions which are based on the combined judgment of contractors and engineers. It is evident that there should be sufficient interest to warrant a more extensive study of these problems so that useful conclusions can be developed.

TABLE II.—Requirements of 48 State Highway Departments for Bonus and Penalty Provisions

State	Days Bid by Contr.	Days Spec. by State	Penalty for Failure to Complete on Time	Bonus for Completion in Less Time
Alabama	No	Yes	$10-80 per day	$10-80 per day
Arizona	No	Yes	Varies with amt. of contract	None
Arkansas	No	Yes	$10-30 per day	None
California	No	Yes	$50 per day	None
Colorado	No	Yes	Varies with Con.	None
Connecticut	Yes	No	Note No. 1	Note No. 1
Delaware	Yes	No	Note No. 1	Note No. 1
Florida	No	Yes	Variable with amt. of contr.	None
Georgia	No	Yes	$10-50 per day	$10-50 per day
Idaho	No	Yes	$25 per day	None
Illinois	No	Yes	$10 plus Eng.	None
Indiana	No	Yes	All ex. costs	None
Iowa	No	Yes	None (Note No. 2)	None
Kansas	No	Yes	$10-50 per day	None
Kentucky	Yes	Yes (Note No. 3)	Varies with amt. of contract	None
Louisiana	Yes (Note No. 4)	Yes	Extra Eng.	None
Maine	Yes	No	Note No. 1	Note No. 1
Maryland	No	Yes	$10 per day	$10 per day
Massachusetts	No	Yes	$25 per day	None
Michigan	No	Yes	Extra eng.	None
Minnesota	No	Yes	$10-30 per day	None
Mississippi	No	Yes	Extra Eng.	None
Missouri	No	Yes	$15 per day	None
Montana	No	Yes	$15 per day	None
Nebraska	No	Yes	None	None
Nevada	No	Yes	Extra Eng.	None
New Hampshire	Yes	No	$25-50-100	$25-50-100
New Jersey	No	Yes	$10-50 per day	None
New Mexico	No	Yes	Extra Eng.	None
New York	No	Yes	Extra Eng.	None
North Carolina	No	Yes	Extra Eng.	None
North Dakota	No	Yes	Extra Eng.	None
Ohio	No	Yes	Cont. Void	None
Oklahoma	No	Yes	$10-75 per day	None
Oregon	No	Yes	Extra Eng.	None
Pennsylvania	No	Yes	$10-80 per day	None
Rhode Island	No	Yes	$10 per day	None
South Carolina	No	Yes	$10-25 per day	$10-25 per day
South Dakota	No	Yes	Extra Eng.	None
Tennessee	Yes	No	$10-80 per day	None
Texas	No	Yes	$10-35 per day	None
Utah	No	Yes	Extra Eng.	None
Vermont	No	Yes	Extra Eng.	None
Virginia	No	Yes	$10 per w. day	$10 per w. day
Washington	No	Yes	$50 per day	None
West Virginia	No	Yes	Extra Eng.	None
Wisconsin	No	Yes	Extra Eng.	None
Wyoming	No	Yes	Varies with con.	None

Note 1—See statement regarding Connecticut.
Note 2—Contractor is required from the start to keep a well organized crew of sufficient size on the work to insure completion within specified time.
Note 3—State fixes maximum number of days which will be considered.
Note 4—State uses both methods.

High Mountains in U. S.

Accurate level lines have now been run by the Geological Survey, Department of the Interior, to six of the high peaks in the eastern part of the United States. Mount Mitchell, in North Carolina, which is probably the highest point in the United States east of the Mississippi River, is 6,684 ft. above mean sea level.

Three peaks in the proposed Great Smoky Mountains National Park are Clingman's Dome, on the North Carolina-Tennessee state line, which has an elevation of 6,642 ft.; Mount Guyot, also on the North Carolina-Tennessee line, 6,621 ft.; and Le Conte (Myrtle Top), in Tennessee, 6,593 ft. Mount Washington, in New Hampshire, is 6,288 ft. above mean sea level, and Mount Katahdin, in Maine, 5,267 ft.

The highest known point in the United States, exclusive of Alaska, is the summit of Mount Whitney, in California, which is 14,496 ft. above sea level, and the lowest known dry land in the United States is in Death Valley, also in California, which is 276 ft. below sea level.

Street Traffic Control Signals

Recommended Practice Given in the Report of the American Engineering Council's Committee on Street Traffic Signs, Signals and Markings

THE work of the National Conference on Street and Highway Safety showed that a valuable public service could be rendered by the establishment of greater uniformity in the use of street traffic signs, signals and markings. The American Engineering Council, a body participating in the conference, offered to make a national survey of the existing conditions and to prepare a recommended practice. The offer was accepted and the council then appointed a Committee on Street Traffic Signs, Signals and Markings. Surveys were made in 35 states, and the returns analyzed were collected in more than 100 cities having a population of more than 33,000,000. It is believed the returns cover all conditions and methods of traffic control. The report of the committee was issued last year and from it we are taking that portion relating to street traffic control signals.

Reasons for the Installation of Signals

The principal reasons why signals to control street traffic should be installed are: (a) to increase the safety of pedestrians and vehicles at congested intersections; (b) to facilitate the movement of traffic with a minimum of delay at congested intersections; (c) to provide for the continuous movement of traffic throughout a heavy route; (d) to interrupt a heavy traffic stream at intervals so as to afford opportunity for cross traffic to move.

The most generally effective mechanical device used to increase safety and to facilitate traffic at intersections on city streets is the automatic traffic control signal, but there is a tendency to use traffic control signals unnecessarily. Some are installed indiscriminately, without a thorough analysis of the conditions and of the probable effects of their installation. Many are installed and operated where and when their use is not justified. The unnecessary use of signals produces serious results. For example:

(a) Impatient and reckless drivers disregard an unnecessary "Stop" signal, and their habit threatens the usefulness of all traffic control signals, the value of which depends upon the public confidence based upon their supposed general observance.

(b) There is likely to be a general diversion of traffic from main thoroughfares to unsignaled side streets, which would increase the volume of traffic and the danger of accidents there, especially to children.

An effort was made to obtain data upon which to base an authoritative statement as to the volume of traffic and the other conditions that justify the installation and operation of an automatic traffic control signal. As no general formula has yet been established as to traffic control signals, the authorities responsible for their installation should examine carefully each proposed installation and base their decision upon the volume and the type of traffic moving in each direction at the point considered in comparison to the number of lanes of roadway width, the layout of the intersection, the method of operation possible, and the like. Where expedition of traffic rather than safety is the paramount consideration care must be taken in installing traffic control signals, because an unwise regulation will retard rather than expedite traffic. Some traffic control signals that are installed to control the peak traffic, such as exists at certain hours of the day, or on Sundays and holidays, should not be operated at other times when the volume of traffic does not warrant such control.

A proposed solution of this problem is the use of a timing device that will automatically pass a small volume of traffic from time to time as it approaches and will automatically go into a fixed cycle when the volume increases sufficiently to require the signal.

Definition of Terms

The use of traffic-control signaling is new; it is in a formative state, and there is confusion as to the meaning of the terms used in connection with it. In the interest of clarity the following definitions are recommended:

Recommendation 49.*—Traffic Control Signal.

"A Signal" shall be defined as comprising all signal lights that are operated together to control traffic at an intersection, whether the signal is mounted in one unit or more.

Recommendation 50.—Types of Housing.

The types of housing shall be defined as follows:

(a) Vertical—Lights one above another.
(b) Horizontal—Lights side by side.
(c) One-Way—Lights visible in only one direction.
(d) Two-Way—Lights visible in two directions, either opposite or at angles.
(e) Three-Way—Lights visible in three directions.
(f) Four-Way—Lights visible in four directions.
(g) Multi-Way—Lights visible in more than four directions at various angles.

*Consecutive number as it appears in the report.

Recommendation 51.—Types of Support.

The types of support shall be defined as follows:

(a) Post—Housing supported on top of a post or pedestal.
(b) Bracket—Housing supported on a bracket projecting from the side of a pole.
(c) Cable—Housing suspended over the roadway by one or more cables.

Recommendation 52. — Methods of Operating Traffic Control Signal Systems.

The methods of operating traffic control signal systems shall be defined as follows:

(a) Manual—Direct control by a hand switch.
(b) Automatic — Control by motor, clock work, or other mechanism.
(c) Combined—Automatic control that can also be operated manually.

Classification of Traffic Control Signal Systems

Traffic control systems should be classified to the character of the traffic movement resulting from the system rather than the type of apparatus employed. The use of the following classification, which is stated in terms of traffic flow and arranged in the sequence of the development of the art, is therefore recommended.

Recommendation 53.—Types of Systems.

Traffic control signals and signal systems shall be classified as follows:

(a) Independent. The operation of the signal is not related to the operation of any other signal. Isolated intersections that are controlled by independent traffic signals, not related in operation to any other signals, cannot be said to form a traffic control system.

(b) Synchronized. A type of coordinated control in which all signals show the same color in the same direction simultaneously.

(c) Limited Progressive. A form of progressive system in which the signals are grouped, the alternate groups showing opposite colors in a given direction and all signals simultaneously.

(d) Flexible Progressive. A form of progressive system in which the operation of each signal is determined by the traffic requirements of the intersection and which in addition provides for the continuous movement of traffic.

Selection of Method of Operation

Where the traffic conditions require the installation of traffic control signals at a number of neighboring intersections along a main thoroughfare or on a number of adjacent streets, so that

each signal will affect the traffic flow at the others, it is essential to select some control system. To aid in such selection the outstanding features of those now commonly used are here described in the order of preference.

Flexible Progressive System.—The flexible progressive system is the best for the coordination of signals along a single street and is the only one that is well adapted to the control of signals on a number of adjacent streets that form a district. Its only limitation is that the complete cycle of changes must be of the same duration for all the intersections controlled. It has the following advantages:

(1) It permits the continuous movement of traffic at approximately a predetermined speed on both through and cross streets.

(2) It makes possible the adjustment of the timing of each signal to the variations in the flow of traffic at the particular intersection controlled by that signal.

(3) It discourages speeding, because it forces the driver of a vehicle to make frequent stops if he exceeds the speed determined for the system.

(4) It permits modification of the timing throughout a considerable area to adjust it to the differences in the movement of traffic at different hours of the day.

Limited Progressive System.—The limited progressive system is an adaptation of the synchronized system obtained by so changing the wiring of alternate signals or groups of signals that each signal or group as seen from the same direction shows the color having the meaning opposite to that conveyed by the adjacent signal or group. Under the conditions for which this system is satisfactory it has the following advantages:

(1) It permits the continuous movement of traffic on a single street at approximately a predetermined speed, subject to the limitations stated in paragraph (c) below.

(2) It discourages speeding, because a vehicle is forced to make frequent stops if it exceeds the speed for which the system is arranged.

It has the following disadvantages:

(1) It is not well adapted to a street having bocks of unequal length.

(2) It requires equal time intervals for through traffic and for cross traffic, so that too much time is devoted to cross traffic on a street where there is a greater volume of through traffic.

(3) If the signals are grouped it reduces the capacity of the street between points where the color changes, because only the vehicles that enter the first intersection of a group during the first part of the green interval can move continuously.

Synchronized System.—The synchronized system is simple, but it has the following disadvantages:

(1) It necessitates the stopping of all traffic simultaneously in one direction, so that the continuous movement of vehicles is impossible and the overall speed and the average speed are low.

(2) On streets traversed by electric railways, it increases the peak power load, because of the simultaneous starting of many street cars.

(3) It encourages speeding in order to pass as many intersections as possible before a change of signals.

(4) The timing is based on the flow of traffic at the most congested intersection, and as the timing at all intersections must be the same, the traffic at the other intersections is unnecessarily delayed.

Independent Signal.—The independent signal is used at isolated intersections as a safeguard to intersecting lines of vehicular traffic where the traffic is heavy on each line. Independent signals can often be used effectively, at intervals of several blocks, as interruptive devices to break the flow of traffic on a heavily traveled thoroughfare, such as a "through traffic street" in order to enable pedestrians and vehicular traffic on side streets to cross in safety. (See Rec. 64.)

Use of Colors

The general practice in traffic control systems in the United States and that recommended in the Model Municipal Traffic Ordinance is to use three colors, but in some cities only two colors are used.

Recommendation 54.—Three-Color System.

(a) If a three-color system is used the colors shall be displayed in the order red, green, yellow.

The display of yellow after red is not recommended because it is likely to be interpreted by the waiting driver as an invitation to start before the green appears. Therefore, the red should be shown until the change is made to green and the yellow should be displayed after the green. In recent installations in some cities yellow is displayed before the end of the green so that the two colors show simultaneously. Experimentation is also being carried on with yellow overlapping with and continuing after green.

Recommendation 55.—Meaning of Colors in Three-Color System.

In a three-color system the colors shall be interpreted respectively as follows:

(a) Red means Stop before entering the intersection and remain standing until green is shown.

(b) Green means permission to Go, subject to safety of others or to the specific directions of a police officer.

(c) Yellow after green means stop before entering the intersection unless when yellow first appears the vehicle is so close to the intersection that it cannot be stopped with safety.

(d) Yellow shall not be used in traffic control systems to govern the turning of vehicles or the movement of pedestrians.

At some intersections where pedestrian movement in all directions is heavy at times, especially if combined with complicated vehicular turns, it has been found necessary to set aside a time interval for exclusive pedestrian use of the intersection. As stated, the use of yellow alone in such a case is not recommended because it would conflict with the standard significance of that color. A special color, such as purple, or a combination of yellow with red showing in all directions can be used to indicate exclusive pedestrian movement.

Recommendation 56.—Two-Color System.

(a) If a two-color system is used, the colors shall be red and green, and the red shall be displayed simultaneously in all directions for the change period.

It is not recommended that the change period be indicated by a dark interval, during which no lights are shown.

Recommendation 57.—Meaning of Colors in Two-Color System.

In a two-color system the colors shall be interpreted as follows:

(a) Red means Stop before entering the intersection and remain standing until green is shown unless when the red appears the vehicle is so close to the intersection that it cannot be stopped with safety.

(b) Green means permission to Go, subject to the safety of others or to the specific directions of a police officer.

The determination whether or not a vehicle can be safely stopped before entering an intersection after the appearance of a stop signal should be based upon normal braking distances as defined in the National Code on Brakes and Brake Testing.

Recommendation 58.—Removal of Confusing Colored Lights.

All lights of such a color and location as to be confused with traffic control signals should be removed.

Recommendation 59.—Right and Left Turns.

(a) Turn either to the right or the left should be prohibited while the red is shown and permitted only while the green is shown.

(b) There may be reasons for making exceptions to this rule in certain places, but such exceptions should be avoided if possible. In such places, an auxiliary green arrow should be displayed pointing in the direction in which traffic is permitted to turn.

Recommendation 60.—Signal Specifications.

(a) The visible diameter of a signal lens shall be 8 inches.

(b) The illuminating lamp shall be of not less than 60-watt capacity.

(c) The optical system shall be so designed that each lens shall be illuminated independently of any other lens.

(d) The lens, reflector, and visor shall be of such design as to minimize the effect of all phantom light and to render the signal light plainly visible for a distance of 300 feet under all conditions.

(e) The relative position of the colors shall be:

(a) Vertical: Top, red; middle, yellow, if used; bottom, green.

(b) Horizontal: Left, red; middle, yellow, if used; right, green.

Recommendation 61.—Location of Signals.

(a) All traffic control signals shall be so placed that the lights are plainly visible to the drivers of the traffic to be regulated.

(b) The type and location of lights shall be as follows, named in the order of preference:

1. Four-way signal on post or bracket on each corner.
2. Three, two, or one-way signal on post or bracket on each far corner.
3. Three-way or two-way signal on post or bracket on each near corner.
4. Four-way signal suspended over center of intersection.
5. Four-way signal on post on safety island.
6. Four-way or two-way signal on brackets on diagonal corners.

Four-way signals at each corner are placed first in order of preference because they give traffic a maximum of information as to what is required, without introducing any obstruction. At least one signal light is always readily seen by the vehicle operator. The pedestrian on either crosswalk also directly faces a signal light.

Signals on the far corners alone are preferable to those on the near corners alone because the latter cannot readily be seen by the driver stopped alongside them. Far-corner signals are sometime obscured, however, by cross traffic. If they are not to show in all four directions as many directions as possible are desirable.

Signals suspended over the center of the intersection must be high to avoid interference with high vehicles, and therefore cannot be seen by operators in certain types of vehicles when stopped at the entrance of the intersection. The cable suspension is unsightly, difficult to maintain and may interfere seriously with fire-fighting equipment.

The use of four-way signals on posts on safety islands is limited in application to streets wide enough and with sufficient pedestrian and vehicle traffic to warrant such islands. The use of post signals in the centers of intersections is not recommended, because they form unnecessary and dangerous obstructions.

Signal lights on brackets on two diagonally opposite corners are the least desirable of the approved forms because the signal is on the right for one driver and the left for the other, because the lights must be high to clear vehicles and because the bracket must be long and cumbersome to carry the signal far enough outward to show on two streets.

Only one type of location should be used in each city. It would be most advantageous if neighboring municipalities used the same type. It is suggested that appropriate information as to the type of location, the character of the signal system, and the like, be included on signs posted at the principal highway entrances of each municipality.

Recommendation 62.—Main Thoroughfare Traffic Control.

(a) Where traffic is controlled continuously for a considerable ditsance each intersection of a main thoroughfare with a cross street shall be protected.

The practice of using a few widely separated traffic control signals on a main thoroughfare to control all intersections on that thoroughfare is exceedingly dangerous and is not recommended.

The type of signal to be installed at each intersection on a main thoroughfare must depend upon the volume of traffic carried by the cross streets. Where signals are installed on given main thoroughfares the following recommendations shall apply.

Recommendation 63.—Main Thoroughfare and Heavy-Traffic Cross Street.

Each intersection of the main thoroughfare and heavy-traffic cross street shall be protected by a traffic control signal.

Recommendation 64.—Main Thoroughfare and Light-Traffic Cross Street.

Each intersection of the main thoroughfare and light-traffic cross street shall be protected by a sign lettered "STOP Through Traffic." (See Rec. 11.)

A "STOP Through Traffic" sign is used at the intersection of a main thoroughfare with a light-traffic cross street because a main thoroughfare can carry a greater volume of traffic and can carry it at a higher speed if the movement of the traffic is impeded only at cross streets on which the traffic is heavy. On main thoroughfares where the traffic is heavy, traffic control signals preferably should be installed at certain intersections, even where there is no considerable cross traffic, in order to break the traffic streams into platoons that will afford predestrians and vehicles an opportunity to cross. Such signals should be arranged in a flexible progressive system, provided that the signalled intersections are close enough to permit vehicle drivers in general to take advantage of the progressive timing arrangement.

Recommendation 65.—Height of Signals.

(a) All traffic control signals shall be placed at such height as to be plainly visible to drivers in approaching traffic at a distance of 100 feet from the intersection.

(b) The bottom of the housing shall be 7 to 10 feet above the pavement if it is inside the curb line and at least 14 feet above if it is supported on brackets or cables over the roadway.

Emergency Control

In any coordinated system supplemental arangements may be provided for breaking the system into small units for em rgency operation, such as runs of fire apparatus.

Cycle Lengths

The length of the cycle should be determined by a careful consideration of all the factors involved in the regulation, such as volume of through and cross traffic, turning movements, distances between intersections, average speed obtainable at different hours, classes of vehicles, street car schedule, street-car speeds and loading times, number of lanes available, requirements of pedestrians, and any irregularity in the shape of the intersection. In general, short cycles are more effective than long ones, and proper timing on short cycles encourages the observance of the regulations by pedestrians.

Recommendation 66.—Timing of Cycles.

(a) A cycle length of 40 to 80 seconds should be used for the control of ordinary traffic.

(b) Changes in cycle lengths for rush hours may be advisable. Consequently timers (or controllers) should have flexiblity of adjustment through a wide variation of cycle lengths.

(c) Traffic control signals should not be operated at times when the volume of traffic is too light to justify their operation. They should be so arranged that when they are not in operation that fact will be clearly indicated, preferably by a flashing yellow light on the signal.

Other Signals

Recommendation 67.—Train Approach Signals.

Two well recognized types of signals are now used to indicate the approach of a train at a grade crossing. They are equally visible, and either may be used, namely:

(a) A signal that swings a target and a red light across the highway.

(b) A signal that flashes alternately two red lights, which are in a horizontal line 30 inches apart.

Regular street traffic control signals are sometimes used at railroad crossings particularly within city limits. Their use is enforceable under city ordinaces but they should be used instead of the foregoing standard signal only if operated manually, or by combined automatic and manual control under supervision. If not operated continuously the standard train approach signal should be used when the traffic control signal is not in operation.

Recommendation 68.—Beacon Signals.

Beacon signals shall conform to the following speciafications:

(a) Flashing red means stop and proceed when safe.

(b) Flashing yellow means proceed with caution.

(c) Beacon supports in the roadway shall be illuminated.

Beacon signals have been used extensively and for many purposes in regulating traffic. They should be used to mark permanent street obstructions, such as safety zones, bridge structures, posts, and abutments, and also to mark danger points, such as the end of a street, either at a dead-end or at a cross street, the beacon to be placed on the curb of the cross street opposite the center of the terminating street. They may also be used in connection with stop and cautionary signs. The location of beacon signals at points where they will obstruct traffic is not recommended. (See Section on Signs.)

Recommendation 69.—Lighting of Traffic Officers.

Traffic officers stationed in roadways shall be illuminated at night by flood lights if necessary, in the interest of safety.

Methods of Disposing of Street Dirt and Catch Basin Muck

The economical disposal of dirt resulting from street cleaning and muck removed from catch basins is an important problem.

How this work is handled at Toronto Ont., was decided by H. D. Bradley, Deputy Street Commission, in a paper presented at the 1929 conference of the International Association of Street Sanitation Officials. The paper follows:

Toronto has 565 miles of streets, 480 of which are paved; 315 of the paved roadway is asphalt, 87 miles bitulithic, 25 miles brick, 20 miles concrete, and 15 miles asphaltic concrete. The remainder consists of the older types of roadways, some of which were laid for experiment and which are being gradually replaced each year with asphalt.

Throughout this mileage 50,600 gullies and catch-basins are provided to take care of the surface drainage.

The cleaning of this area of improved roadways amounting to 7,610,000 square yards is an extensive task, and the regularity with which the work is done has a direct bearing upon catch-basin cleaning. It lessens the danger of gratings and traps becoming blocked during heavy rainstorms, thereby reducing the hazard of flooding and subsequent claims for property damage.

The patrol system is used entirely in the downtown section, business areas, and on main thoroughfares. Each patrolman is provided with a carrier, set of metal tubs, each with a capacity of 3 cubic feet, push broom, and scraper. As the tubs are filled, the patrolman leaves them at a designated point to be collected. The streets under the patrol system receive constant cleaning, and may be covered from two to eight times each day according to the district. The remaining section is under the squad system, the men working in pairs followed by a pick-up vehicle, the streets under this system being covered once or twice a week.

The horse-drawn 4-yard wagon is used for pick-up work in certain sections, while the motor truck is used to the greatest advantage for picking up the contents of the patrolman's tubs. At some locations there are from 6 to 8 tubs to be emptied with a capacity of 18 to 24 cu. ft. In the downtown section a 5-ton motor truck is used for collecting the contents of the tubs. The truck is equipped with a steel body and partially enclosed top. A conveyor bucket with a capacity of 8 cu. ft. is attached to the right side of the body operating in channel rails. The bucket ascends vertically to the upper edge of the body, then travels horizontally. The weight of the contents causes the bucket to tip, discharging it into the truck. The bucket is raised by chains through a power take-off on the drive shaft.

The material is disposed of by dumping as land fill, certain shallow areas are used entirely for street dirt. The heavy cleanings in the spring are dumped in ash and rubbish fills.

In the downtown area the street dirt is deposited at a manure contractor's dump, who removes any paper, refuse, etc. and adds it to the manure beds, to be later sold as fertilizer.

Many private applications are received from residents for this material for garden fertilizer. It is delivered free of charge. The Department takes advantage of every application, for it means a short haul and a ready disposition of the dirt.

During the fall, when leaves constitute the greatest bulk of the street dirt, difficulty is experienced at the dumps with the vehicles owing to the spongy nature of the material. The fills are kept as shallow as possible and built up in layers, in order to overcome the vehicles becoming mired.

The Parks Department and several vegetable and flower gardens request fall cleanings for composite heaps or leaf loam, which takes care of a large quantity of leaves at this time of the year.

There are, however, many thousands of yards which can only be disposed of by dumping. During the summer of 1928, 105,600 cubic yards of street sweepings were removed, averaging 13.9 cu. yd. of dirt per 1,000 sq. yd. per season. A daily average of 22 4-yd. wagons, 23 2-yd. carts, and three 2-ton motor trucks were required in the pick-up service, while 200 patrolmen were constantly in service from April until December.

As previously stated, there are 50,600 gulleys and catch-basins to take care of the surface water on our roadways. These are all hand cleaned. The work is carried out systematically after the spring cleanup of the streets. Each street cleaning district is provided with two culvertmen and a pick-up vehicle. They cover the entire district at the first of the season, which is usually sufficient on the residential streets until the fall, when each basin is again thoroughly cleaned in preparation of the winter months.

During the summer months the culverts on main thoroughfares and subways are given such additional service as may be required. It is necessary to give special attention to those located in subways and roadways where there are depressions.

Many householders are of the opinion that the channels are provided on the roadways for the convenience of placing grass-cuttings and lawn rakings in. This practice in the event of heavy rain, is the most common source for blocked gratings and traps, due to the refuse being carried to the gratings by the flow of water, often completely blocking the openings. While on many occasions the catch-basin was found to be the reposing place of a bundle of handbills and circulars which otherwise should have been distributed to the householders in the district.

The cleanings are removed by wagons and a 2-ton motor truck with a watertight body, and disposed of by dumping in rubbish and ash fills. During the season of 1928, 12,600 cu. yd. of catch-basin muck was removed. The nature of the muck is such that it cannot be dumped indiscriminately in every fill, but should be dumped at isolated locations, in order that no nuisance will be created.

There appears to be no means for disposal of street dirt and catch-basin muck, other than that of dumping, and is a matter largely of local conditions. The disposal of street dirt by burning, I do not think, is practicable, owing to the great percentage of inert matter. Perhaps 20 percent would be combustible. There would, however, be no appreciable reduction by weight or volume. Any gain that might be made in this regard would be materially offset by the reduced burning rate of the general refuse.

Fibre for Motor Sweepers. — The question of the kind of fibre for motor sweepers is important. P. J. Hurtgen, Director of Public Works of Kenosha, Wis., in a paper presented at the 1929 conference of the International Association of Street Sanitation Officials, stated that cheap fibre may not be most economical. They had experimented with various fibres and finally concluded that the higher priced fibres swept sufficient additional mileage to warrant its use. They average about 110 lb. of fibre per broom, and get from 200 to 220 miles of service per broom.

The Sources of Highway Income and Present Status of Highway Finance

A Comprehensive Review of the General Status and Character of Highway Financing in the United States

By THOMAS H. MacDONALD
Chief, Bureau of Public Roads, U. S. Department of Agriculture

THE acid test of a sound highway financing policy is its ability to support with unbroken continuity the two essentials of a successful highway program—the perfect maintenance of existing highways and a reasonable annual expansion of modern highway construction. There is no clean cut line of division between highway financing, highway administration, and highway engineering technique. Each is so intimately related to and dependent upon the other two that they stand, succeed, or fail together.

Public and Private Financing.—Public financing, particularly the financing of public works, is of an entirely different character than private financing and much confusion has existed in the public's mind from this fact. The average banking executive, grown wary through contact with relatively short lived corporations and shorter lived individuals, lacks the imagination, initiative, and experience to plan successful financing of a large and long continuing highway improvement financial policy. Formerly there had to be reliance solely upon faith in the profitableness of highway improvement to induce the undertaking of large expenditures. Now there is needed only a knowledge of results actually secured where faith earlier provided for an extensive program of highway development. No country in the world however, as yet, possesses adequate highways—that is, highway mileage in the amount and of the character of improvement that will be profitable to provide. Most of the nations considering their whole extent and needs, certainly those of the Western Continent, have as yet made scarcely more than a beginning toward a really adequate highway system. There is a slow turning from the old bugaboos and fears of disaster through large public expenditures for highways, and a growing recognition of facts which give confidence in such a policy. Full confidence is justified if a major part of the annual expenditure adds to the permanent investment, if the necessary taxes on property are so reasonable the public is willing to continue them indefinitely, and if the taxes upon the road user are so moderate they do not discourage expansion in the utilization of highway transport.

Since the inevitable result of such policies is an accelerated growth in highway traffic, financial policies must be flexible. Without recourse constantly to legislation the income must automatically increase with the expansion in the use of the highways and the road funds must receive the increase in earnings due to previous expenditures.

A $1,300,000,000 Field.—For the five-year period—1923-1928—the total funds for rural highways have averaged over $1,300,000,000 annually. There has been a rather uniform rate of increase and it is probable the total expenditure will continue to increase slowly. There has been a marked change, however, in the relative percentages of income from the various sources. While in 1923 the income from the highway user was only 19.7 per cent of the total—in 1928, after

Concrete Road Construction in Wallacy County, Texas, Showing Hauling, Mixing and Finishing Outfits

an increase in the total expenditure of 68 per cent, the percentage paid by the road user in motor vehicle license fees and gas taxes constituted 35.4 per cent of the whole, a most convincing demonstration of the earning capacity of improved highways to produce a direct income.

The relative place of rural highway expenditures in the business of government is modest. Of the total income for all government purposes, 15 per cent is used for highways. Activities which require higher expenditures are government itself, education, national defense, and the old debts of war.

Every State Could Issue Bonds Profitably.—Much debate has revolved around the matter of road bonds. While in a few of the states there is not the same urge of necessity that existed a few years ago, yet today every state could issue bonds profitably either for primary road building or some of the integral or auxiliary construction needed, such as grade crossing elimination, by-passing traffic congestion and continuous flow routes, that is, routes without cross traffic hazards and interruptions. That the issuance of bonds is an income producing measure is denied and will no doubt be vigorously contested. Nevertheless, intelligently and scientifically adjusted to the needs of the particular state, the issuance of road bonds affords the only way that public credit can be exchanged for physical properties, improved roads, which are income producing and which do have the ability to pay for themselves. There is not a single valid argument against the issuance of bonds for road improvement as a fiscal matter. It is possible for those seeking public office to secure votes against bonds by capitalizing old prejudices and the characteristic human fear of debt. Certainly in the face of the experience of the states which have made the most rapid progress in road improvement and which have advanced a part of the costs from bonds, there is not a single unfavorable situation or circumstance to support anti-bond arguments. Many of the anti arguments wholly false and wholly unsound economically have nevertheless an appeal so widespread and so ready an acceptance that they may be met only by the most careful survey and analysis of the highway needs, the probable future growth of use and the possible revenues from all sources, and all combined in a fiscal and improvement plan that takes the public into full confidence. Only when the confidence and support of the public are secured, and it must be remembered this confidence has been more than once given and betrayed, can there be any hope of the necessary continuity of an adequate fiscal policy. Continuity is here made a major consideration for two important reasons—

A Sound Fiscal Plan Must Be Self Perpetuating.—Since there can be no fixed time when new construction will end, the expected income must provide always a reasonable sum above fixed commitments such as maintenance, bond interest and retirement, and administration costs. This automatically limits the bond principal plus interest which may be retired per year, and with the term of years or life period of the bonds determines the total size of the issue.

The second reason is negative. Any fiscal policy which throws a heavier burden back upon itself and accumulates obligation is not sound and can not be continuous. These results inevitably follow the borrowing of county funds by the state for state road purposes. Once the state has assumed the responsibility for laying out and improving a state road system, the use of county funds and county or other local credit should cease. Such a policy is always more costly and much less efficient. There are now instances of such wastefulness springing from this general cause that the excess and wholly unnecessary cost will equal or exceed the value of the work secured.

Before attempting to devise a rational plan of highway finance, we should have a clear understanding of the magnitude of the task of highway improvement and a knowledge of what has been and is being done to finance the improvement. I shall try, therefore, to picture the problem from both angles, omitting as much as possible of the complicating details and drawing only the lines that are necessary to an appreciation of the general form.

The Magnitude of the Higher Improvement Task.—First let us examine the proportions of the physical job. We find that there are approximately 3,016,000 miles of public rural roads in the United States. Of this total, in 1928, there were 306,000 miles that were included in the state highway systems and 2,710,000 miles were under the jurisdiction of county and other local officials.

In 1921, the year of the passage of the Federal Highway Act, the state systems included only 203,000 miles, which was practically equivalent to 7 per cent of the existing total mileage, the limit that was established for the original Federal-aid system. Since 1921 there have been taken into the state systems an additional 103,000 miles, and the extent of these systems at the beginning of the present year was 10.2 per cent of the total road mileage.

The proportions of the state highway program have thus been increased by 50 per cent in a period of seven years, the annual addition averaging nearly 15,000 miles. In this period of seven years only three states have failed to increase the mileage of their state systems; 11 have added less than 500 miles; 9 have added between 500 and 1,000 miles; 7 have added between 1,000 and 2.000; 10 have added between 2,000 and 5,000 miles; and 8 have increased the size of their systems by more than 5,000 miles.

The percentage of the entire road system embraced within the state system on Dec. 31, 1928, varied from a minimum of 5 to a maximum of 36; the minimum in Oklahoma and South Dakota, the maximum in Rhode Island. Of the three states that have made no addition to their systems, two, Missouri and Oklahoma, still include considerably less than the average percentage of the total mileage; the third, Vermont, has a system which includes 28 per cent of the total road mileage, next to Rhode Island the highest percentage in any state.

Of the eight states that have added more than 5,000 miles in the 7-year period, two—Illinois and Kansas—still include less than the average of 10.2 per cent, the former 10.1 and the latter only 6.7 per cent. Three of this group —Arkansas, Mississippi, and Montana —still include only slightly more than the average percentage, the figures varying from 11.7 to 12.2 per cent. The other three—Kentucky, Louisiana, and New York—by their large additions have increased their respective ratios of state system to total mileage to 18.7, 27.3, and 17.5 per cent, respectively.

Additions to the state highway systems have been made either by legislative enactment or by action of the state highway departments under authority vested in them by the legislatures. There can certainly be no reasonable objection to the placing of a greater mileage of the more important roads under the supervision of the state agencies; on the contrary, such transfer from local control is distinctly desirable and must eventually be made. But addition to the state program without corresponding increase of state revenue is not likely to produce a satisfactory result and is decidedly unfair to the state agency which must shoulder the responsibility.

That is precisely what has been done in too many instances; and a study of the mileage and condition of all of the state systems in conjunction with the revenues available for their improvement and the demand for improvement as indicated by the motor vehicle registration, must lead to the inevitable conclusion that expediency and enthusiasm have been more influential than sound reason in determining the program of state improvement.

Certainly, when we find two adjoining states of similar area, road mileage, and motor vehicle registration; one with nearly 19 per cent of its total mileage in the state system of which but 45 per cent is surfaced and revenue which will permit an expenditure equivalent to only $1,200 per mile of the system and the other with only 9 per cent of its road mileage in the state system of which nearly 80 per cent has been surfaced and annual expenditures equivalent to nearly $3,300 per mile of the system; certainly with

these facts before us we are justified in concluding that reasons other than those of sound business economics have been responsible for the difference.

37 per Cent of State Highway Systems Unsurfaced.—To complete the picture of the physical problem, let us add that of the 306,000 miles in the state systems in 1928, over 113,000 miles, or 37 per cent, were still unsurfaced; 125,000 miles, or 41 per cent, were surfaced with sand-clay, gravel, or macadam; and 68,000 miles, or 22 per cent, were improved with surfaces of bituminous macadam or better. In 1921, of the 203,000 miles then included in the state systems, only 41 per cent was surfaced. In 1928, we find surfaced 63 per cent of the 306,000 miles to which the systems of the states had grown. But there still remains unsurfaced 113,000 miles, or almost as much as the 118,500 miles that were unsurfaced in 1921.

When it is considered that there were 78 motor vehicles for every mile of the enlarged state systems in 1928 and only 50 in 1921 for each mile of the smaller systems, it will be appreciated that the job of the states is still far from finished.

Of the 2,710,000 miles of local roads, 433,000 miles or 16 per cent had been surfaced by the end of last year; but of this surfaced mileage only a little over 34,000 miles, or 8 per cent, was of bituminous macadam or better, a figure that may be compared with the 22 per cent of similar improvements in the state highway systems.

Viewing the roads of the country as a whole, we find that at the end of the year 1928 there was a total surfaced mileage of 626,000 miles of which 193,000, or 30 per cent, were in the state systems; and that of the surfaced total 102,500 miles, or about 16 per cent were improved with surfaces of bituminous macadam or better. Of the surfaces of this higher class, 66 per cent were in the state systems.

The Financial Aspect.—Turning now to the financial aspect, we find first that the total expenditure for the improvement of rural roads in 1928 was, in round figures, $1,660,000,000, of which $828,000,000 was expended by the state highway departments and $832,000,000 by county and other local authorities.

To defray these costs there was available to both state and local authorities income which in varying amounts was derived from the same three general sources; namely, taxes on real property, taxes on motor vehicles and their fuel, and the sale of bonds and notes. In addition, the states drew a portion of their income from Federal aid. A portion of the income drawn from these sources by the states was transferred to the counties and other local units. A portion collected by the local authorities was transferred to the states. Of these transfers it is difficult to ascertain the original source. There are also certain amounts derived by appropriation and certain miscellaneous items the source of which is not entirely clear, but these may be considered as coming in the main from the taxation of property.

Classification of Highway Income.—With this explanation it is possible to classify the $849,000,000 of income to the states in 1928 approximately as follows:

	Per Cent
Sale of bonds and notes	14.3
Property taxes	7.9
Motor vehicle fees	30.5
Gasoline taxes	27.6
Funds transferred by local authorities	10.2
Federal aid	9.5

The income of $835,000,000 accruing for local road purposes in 1928 may be similarly classified as follows:

	Per Cent
Sale of bonds and notes	18.0
Property taxes	65.9
Motor vehicle fees	6.0
Gasoline taxes	6.4
Funds transferred by the state	3.7

The income of the states, now $849,000,000, was in 1923 only $467,500,000, but little more than half the present sum. Of the smaller sum collected in the earlier year the several sources contributed as follows:

	Per Cent
Bonds and notes	18.9
Property taxes	16.5
Motor vehicle fees	31.4
Gasoline taxes	3.4
Transfers from local units	14.3
Federal aid	15.5
Total	100.0

What the Analysis of Income Sources Shows.—From such an analysis several pertinent facts appear. First, with respect to state highways it is evident that the major source of income is taxation of the motor vehicle and its fuel. The sum of $493,000,000, or 58.1 per cent of the total state highway income was allotted from these sources to the states in 1928. Five years previously the same sources contributed to the state highways only $163,000,000; and the increase in revenue from these sources alone, amounting as it does to $330,000,000 for the year, accounts for nearly all of the increase of $381,800,000 in annual state highway revenue during this 5-year period.

Of the total revenue collected in 1928 from motor vehicle fees and gasoline taxes, a portion was used to defray the expense of collection and administration, a portion was allotted to county and local road purposes, and various portions were devoted to purposes other than rural highway improvement, principally to schools and city streets. If all of this revenue, after deducting the collection and administrative costs, had been devoted to the improvement of state highways, the total of $612,000,000 would have paid three-fourths of the state highway bill of 1928.

It should be noted here, however, that the trend in the use of these funds is not toward their concentration upon state highways but rather in the opposite direction. In 1921 local highway authorities received 23 per cent of the motor vehicle fees allotted to highway purposes. In 1928 the same authorities received 28 per cent of the sum allotted to highways, and the trend in the intervening period has been more or less steadily upward. In 1928 there were allotments from the gasoline tax revenues to purposes foreign to rural highways of some 6 per cent of the total collections, and there is active demand particularly by the cities for the diversion of far greater sums from this source to city streets.

A second fact that stands out from the analysis of the 1928 highway income is that the states depend to only a small extent upon property taxes for the support of state road improvement. It may be assumed that the 7.9 per cent of the total state revenue drawn from this source is fairly representative of the general benefit derived by all property owners from the improvement of the state systems. The counties, on the other hand, obtain from this source nearly two-thirds of their total income.

It is interesting to note that the

An Indiana Road with Light Bituminous Retread Treatment

Grade Separation in Detroit. The Center of Grand Blvd. Passes Under E. Jefferson Ave.

states receive from the counties and other local units on the one hand and from the Federal government on the other substantially the same amounts and percentages of their total income. Since 1923 the amounts received from the two sources have varied but slightly and have constituted steadily decreasing percentages of the state income as the motor vehicle revenues have increased in amount. In 1923 the sum received from the local units was 14.3 per cent of the total receipts of the states; that received from the Federal government was 15.5 per cent of the total. In 1928 the receipts from local units were 10.2 per cent of the total and Federal aid had dropped in relative importance to 9.5 per cent of the total state income.

Highway Income from Bonds and Notes.—The item to which I wish to direct your special attention, however, is the portion of this highway income, state and local, that is derived from the sale of bonds and notes. Of the total state income in 1928 the sum derived from this source was 14.3 per cent. In 1923 the corresponding percentage was 18.9, and the trend in subsequent years has been generally downward to the present level. The 1928 percentage represents an actual sum of approximately $121,500,000 drawn by the states from this source, which may be compared with the sum of $150,200,000, or 18 per cent of the total local highway revenue raised by the sale of bonds in the same year.

We have heard so frequently the solemn warning to "pay as you go," and so often have we listened to the tale of woe that impends for those profligate commonwealths that issue bonds, that I fear we may come to believe that there is something peculiarly virtuous in the direct investment of current revenue, and something unspeakably vile in the capitalization of income to create facilities capable of producing greater income.

When fanatical advocates of the pay-as-you-go plan utter their dire prophecies of the disaster that must follow upon the heels of a borrowing policy, I am constrained to doubt by the knowledge of the remarkable benefits that have attended that policy in the states that have made the greatest advances in the improvement of their highways. These gentlemen would have us believe that there are certain commonwealths whose people, preserving the ancient American ideals of honesty and frugality, rigidly refrain from the borrowing of capital for road improvement as a matter of principle. To believe them is to believe that these homely ideals continue to reside in just one of our 48 states, for there is just one—the State of North Dakota—in which thus far there has been no resort to bond issues either for state or local road improvement. If state bond issues alone are immoral, then there are 17 sovereign states that are free of taint, but the other 31 stand convicted by their records.

Borrowing Record of Counties and States.—"Neither a borrower nor a lender be," runs the old adage. It is the rule of finance to which the pay-as-you-go advocate would have us adhere; but if it is really an economic sin to borrow capital for public works, then it must be none the less sinful when the borrowing is done by counties than when it is done by states. To fix the measure of guilt that is to be attributed to the people of each one of 47 guilty states, therefore, we must examine the borrowing record of both the counties and the states. Suppose we do so.

We find, as I have said, that there are 31 states which at some time or other between 1894 and 1928 authorized and issued state highway and bridge bonds. The total of such authorized issues is $1,391,216,500; but the total thus far issued, including refunding securities, is $996,226,100, and of this amount there had been retired by the end of the fiscal year 1928, $103,746,670, leaving an outstanding indebtedness of $892,479,430. The fact that there were sinking fund accruals which would still further reduce the debt by over $83,000,000 is scarcely worth mentioning; but I should like to point out in passing that this state highway debt of the 31 states is approximately equivalent to one year's expenditure for state highways by all of the states.

Now let us examine the record of the counties and other local units of government. We have no complete record of the bonds authorized; nor have we a compilation of any sort of later date than 1926. For that year we have a record of the county and local highway and bridge bonds then outstanding, and the total in 45 states was $1,386,338,683, a total 55 per cent greater than the outstanding state debt in 1928. In only three states was there no outstanding local debt for highways or bridges. They were New Hampshire, Vermont, and North Dakota, and only the last was also free of state indebtedness.

If as we are frequently told there are states the people of which refuse as a matter of principle to incur a public debt, then presumably we should find them among the 17 that have thus far incurred no state debt. We already know that in all but one of these there have been issues of local bonds; but perhaps there have been mere occasional lapses from rectitude. Let us see.

What we find on examining the record further is that in these 17 states that have issued no state bonds the outstanding local issues in 1926 amounted to $657,072,787; and that the issues outstanding at the same time in the other 31 states amounted to $729,265,896. In the 17 states there are 1,354,500 miles of local roads; in the 31 there are 1,355,300 miles of corresponding class. The outstanding local bond issues in the 17 that have issued no state bonds amounted, therefore, to $485 per mile of local road; those outstanding in the other 31 states of less conservative state policy amount to $540 per mile of local road. If, therefore, it is true that the people of the 17 states do object to the issuance of state bonds, it appears that their objection does not extend to the issuance of county and local bonds. Perhaps they hope to be forgiven of their sin by the payment of the higher rate of interest.

Since there is really so much of this bonding by local units of government even in states that have refrained as states, the only way in which we shall see clearly the extent to which the practice is indulged in, is by throwing together the debt of the states and the local units in the states in which both

have borrowed. Then if we also lump together the existing mileage of improved roads built by the states and local units we shall see what the people of these two groups of states have gotten for their more or less reckless borrowing.

Comparison of Debts and Total Mileage of Surface Roads.—We find that the people of the 17 states that have issued no state bonds have 32,066 miles of roads improved with surfaces of bituminous macadam or better to show for their debt of $657,072,787. For each mile of such high-type roads, there is or was in 1926 an outstanding indebtedness of $20,500 per mile, on every dollar of which they are paying a relatively high rate of interest.

The people of the other 31 states have a combined state and county indebtedness (ignoring the different dates of the records) of $1,621,745,426, to show for which they have 70,493 miles of roads with surfaces equal to or better than bituminous macadam. The indebtedness is at the rate of $23,000 per mile of such high-type roads; and on more than half of it the people are paying a minimum rate of interest.

If it be preferable to compare the debts of these two groups of states on the basis of their total surfaced mileage rather than simply the mileage of high-type surfaces, it is necessary to consider that the improvements in the 31 states are of distinctly higher average type than those of the 17 states. In order to arrive at an average appraisal per mile, it is necessary to apply some uniform scale of value to the known mileages of each type of improvement in each group of states. As to this scale, ideas may differ; but for purposes of illustration we may adopt the following as representing the average capital investment in a mile of the several common types:

Type	Investment per Mile
Sand-clay	$ 8,000
Gravel	10,000
Macadam	15,000
Bituminous macadam	25,000
Bituminous concrete	30,000
Concrete	35,000
Brick	40,000

Applying this scale we find that the average investment in each mile, of the 296,056 miles of state and local surfaced roads in the group of 17 states, is $12,500 and against each mile there is an average debt of $2,220. In the group of 31 states the average investment in each mile of the 330,081 miles of state and local surfaced roads is $15,000, and against each of these miles there is a combined State and local debt of $4,915. The difference in the indebtedness approximately equals the difference in investment.

Let us now consider the county and local income alone in these two groups of states. We find that the totals for the two groups differ by less than 20 million dollars, being $446,200,000 approximately in the group of 17 states that have no state bonds, and $465,000,000 in the group of 31 states that have issued state bonds. The figures are for 1928. When we look to the proportion of this income that was derived from the sale of bonds, we find that in the group of 17 States it was 23 per cent and in the group of 31 it was 15 per cent of the total. In other words, the people who are supposed to oppose bond issues are actually issuing high-interest local bonds in considerably greater proportion to their total local highway income than the people who presumably favor the issuance of bonds.

Transfers of Income Between State and Local Governments.—One more comparison and I am through with these interesting groups of states. I have referred to the transfers of income that take place annually between the states and their local units of government. In the large majority of the states, it works both ways. The counties and townships give and receive. The states receive and give. But apparently the local units are generally convinced that it is more blessed to give than to receive. At any rate, the fact is that 33 of the states actually do receive from their local units more than they give in return.

Of the group of 17 states, all but 3 are net beneficiaries by this practice, and the net gain to the states of this group is approximately $59,200,000. Of the group of 31 states, 20 are similarly benefited by the interchange, although in smaller amount than their 17 sisters. In this group, the net gain to the states is roundly $16,700,000. Of special interest here is the fact that the gain to the 17 states is 21 per cent of their total state income, and the profit of the 31 states is but 3 per cent of their total income.

The motor vehicle fees and gasoline taxes turned over to the counties are not considered in the foregoing analysis as transfers from the states. Though they are in fact collected by the states they are presumed to belong to the counties by law. However, when we analyze the amount of these returns in the two groups of states, we find that the counties of the group of 17 states get approximately $52,000,000 of a total of $219,700,000 available for highway purposes, and those of the group of 31 states get practically the same amount from a total of $377,800,000. In other words the counties in the group of 17 states get 24 per cent of the total and those of the 31 states get only 14 per cent.

I submit that it all comes down to this: That it is generally true that the states that do not issue state bonds for highway purposes return to the counties a greater proportion of the motor vehicle revenues which the counties use to borrow money at high rates of interest in order to help the state eke out their deficient debt-free income.

I do not wish to be understood as favoring the issuance of bonds under all circumstances. I have said that I believe there are a few states in which there is no longer the need that existed a few years ago for the employment of this method of financing. But I also repeat that every state can still profitably issue bonds for certain purposes, if not for primary highway building, then for grade crossing elimination, or needed bridges, or the provision of additional facilities for the relief of traffic congestion, or for any of the numerous improvements which remain to be accomplished in order to raise the efficiency of highway service to the desirable ultimate.

Advantages of the Bond Issue Plan.—The outstanding advantage of the bond issue plan may be briefly stated as follows:

1. A rational system of roads economically in need of improvement may be planned and their improvement pushed to completion as rapidly as the physical limitations of plant, equipment, labor and materials will permit.

2. Present low current income may be capitalized for the creation of income-producing facilities which share the payment.

Mixed in Place Surface, with Road Oil Used as Binder, Shortly after Completion

3. The improved roads are built in a minimum time and vehicle operating cost savings are realized sooner than they would be under the pay-as-you-go plan.

4. Payment is more equitably divided between present and future users.

5. Savings in cost of construction are made through ability to let large contracts.

6. The roads produce wealth immediately in excess of the debt they create.

7. Maintenance costs are lowered.

Relative Costs of Construction by Two Methods of Financing.—But what of the actual dollars and cents cost of the two methods? If we borrow money we must pay interest. Consequently we pay considerably more than a dollar for every dollar obtained for road construction. Would it not be better to pay the cost directly and so save the additional cost of borrowing? If, without undue burden of taxation the roads can be built as rapidly as it is possible to build them, the answer is "yes." If road service is already reasonably efficient and economical transportation is already provided for in large degree, the answer is "yes." But these conditions obtain in few of our states.

To illustrate the relative costs of construction by the two methods of financing, and at the same time to show why it is sound economics to pay the additional cost of the bond method in order to speed up construction, let me cite an example based on an actual bond issue, the $60,000,000 issue voted in Illinois in 1918. The interest rate on these bonds is 4 per cent. Payment of interest began in 1922. Retirement began in 1926. It is planned to compete retirement in 1944 and on this basis the total interest payment will be $33,200,000. For each dollar borrowed the state will pay $1.55. The bond issue sold for $58,496,978 in the years 1921 to 1924, inclusive. The roads built average $39,394 per mile, and the money realized paid for 1,480 miles which weer completed by 1925. Amortization is spread over a period of 23 years, making an average annual payment of $4,052,200.

Now let us suppose that instead of issuing the bonds this same average annual sum had been used to pay for these roads directly. It would then have taken 15 years to complete the roads which under the bond plan were completed in 5 years. In other words, the 1,480 miles of road were available for an average period of years under the bond plan before they would have been available under the pay-as-you-go plan.

So much is actual fact. Now we must make one or two assumptions. We will make them conservatively. We must estimate the number of vehicles these 1,480 miles of paved road would serve for the period of 5 years and the saving in operating cost that would be returned to the operators of these vehicles by the availability of the improved roads. Let us estimate that each mile of these roads will be used every day of the 5 years by an average of only 1,000 vehicles and that the saving to the owners of these vehicles is 1½ cents per mile. Both of these estimates will be considered, I believe, as sufficiently conservative. The result is an estimated saving of $40,515,000 in operating cost over the 5-year period, by which improved highway service has been advanced, which exceeds the interest cost on the bond issue by $7,315,000.

There is still more to be said about this bond issue. It was financed exclusively with motor vehicle revenues, and no increase in the rate of motor vehicle taxation was permitted. In 1921, when the first bonds were sold, receipts of motor vehicle revenues amounted to $6,803,556. In 1928, seven years later, annual receipts had increased to $15,521,530. In other words, the personal liability of the motor vehicle owners who assumed the debt in 1921 was cut in half by 1928.

The use of motor vehicle revenues to finance bond issues dates from 1913. Prior to that year all issues of state highway bonds were financed from the proceeds of general property taxes. In 1913, Maine began to issue bonds at the rate of $500,000 a year for highway purposes, the issues to be financed from the proceeds of the motor vehicle tax. The procedure, which came to be known as the "Maine plan," proved its soundness in practice, and other states were quick to adopt it. As a result we find that of all issues authorized between 1894 and 1928, totaling $1,391,716,500, the sum of $670,374,000 is being financed either from motor vehicle fees or gasoline taxes, or both. Of the remainder, $14,500,000 are being financed from bridge tolls, and $706,842,500 from general state revenues. Of this latter amount, $300,000,000 is the amount of the New York issue for grade separation purposes, and of the balance of $406,842,500, half was authorized and issued prior to 1919, when the first gasoline tax measure was adopted.

There can be no question that the employment of motor vehicle revenues to pay for bonds is now the proper procedure.

Relative Contributions of City and Country.—There is one other question that must be answered to round out a fairly complete picture of the sources of highway income and the present status of highway finance. That is the question as to the relative contributions of those who live in cities and those who live in the country. The statistics which would permit of a complete answer have not been found, but facts are available which are strongly indicative. The current revenue for highway purposes comes from just three principal sources; namely, the Federal Treasury, taxes on real and personal property and taxes on motor vehicles and their fuel. The Federal contribution may here be ignored. It is relatively small and is presumably spread quite generally over the entire population.

As to the contribution of the motor vehicles, we find that according to the estimates compiled by the Farm Journal, the only existing source, 5,427,000 of the 24,493,000 motor vehicles registered in 1928, or 22 per cent of the total, were farm-owned. The estimates made annually since 1922 show a steady decline in the percentage of farm ownership. If they may be assumed to be approximately correct, then the contribution of farmers to current highway income through motor vehicle and gasoline taxes is at present not more than 22 per cent of the total of such revenues. As farm-owned vehicles are in general lighter than the average and generally use less gasoline per car than city-owned cars, it is probable that the actual contribution to motor vehicle revenues by farmers is actually less than the 22 per cent indicated by the registration figures.

Revenue from Property Taxation.—With respect to the portion of current revenue derived from taxation of property, I have found no complete statistics. Real property is taxed by the state in 43 states. It is taxed by the counties in 46 states. It is from these taxes that the general-tax revenue for highways is derived.

In the state of Ohio, which may not be quite representative of the average, but which is the only source from which I have been able to obtain satisfactory data, I find that 26 per cent of the total valuation of real and personal property is classed as rural, the remaining 74 per cent is urban. The tax revenue is, of course, proportional to the valuation, and the indications are that, in Ohio at least, rural property pays approximately a quarter of the total general-tax revenue for highways.

Another indication of the possible extent of the respective contributions of rural and urban property is found in the census classification of population. The Census of 1920 showed that 51.4 per cent of the total population at that time was urban. The urban percentage of total property value is doubtless higher; and it would probably not be far from correct to say that the average urban percentage is approximately 60 per cent.

If, then, we assume that 20 per cent of the motor vehicle revenues and 40 per cent of the property tax revenues are contributed by persons resident in the country, we find that of the total current highway revenue of states and counties, exclusive of Federal aid, approximately 30 per cent is paid by persons who live in the country and 70 per cent by persons who live in cities and towns. The corresponding per-

centages of current state highway revenue are:

	Per Cent
Rural	22
Urban	78

For current local highway revenue they are:

	Per Cent
Rural	37
Urban	63

From this review of the general status and character of highway finance in the United States, I think we may draw certain rather definite conclusions as to the policies most likely to yield success.

Policies Most Likely to Be Successful.—The first is that there is need for more scientific and businesslike financing and administration of highway improvement, which should start with a selection of the roads to be improved according to their relative traffic importance, and an allocation of authority to state and county authorities on the same basis. It is apparent that there is still much to be desired in this respect. Differences between the percentage of total mileage included in the state systems of neighboring states of approximately the same general culture and development, as shown by the records, are too great to be accounted for upon any reasonable basis. So also are the differences too great between the annual expenditures per mile of state system in states that have systems of approximately the same extent and average traffic density approximately equal.

Highway building is a gigantic business. It should be conducted in a businesslike way. There is no excuse for inequitable allocation of funds or wasteful expenditure. The traffic survey furnishes a reliable means of determining such questions as the proper size of state systems, and necessary expenditures upon the several parts of the systems. It should be more generally employed as the basis of highway planning and budgeting.

We should put an end to this merry-go-round of income transfer between the states and the counties. As I have shown, the counties are rather generally the losers, and they can ill afford the loss.

We should face more frankly than we have, the question of indebtedness for highway purposes. The public loses, and loses heavily when, to avoid a state debt, the counties are thrust into debts on which they must necessarily pay a high rate of interest.

Sound highway financing implies as essential adjuncts:

First, reasonable security of tenure for competent executive officials; second, honest and businesslike administration; third, complete and accurate accounting; and fourth, adequate maintenance of the roads in which the public capital is invested.

Acknowledgment.—The foregoing is an address presented at the annual meeting of the Association of State Highway Officials.

Asphalt Producers Form Institute

The Asphalt Institute, a new organization whose membership is made up of the producers of asphalt and asphaltic oil responsible for more than 90 per cent of the production east of the Rocky Mountains, succeeded The Asphalt Association on Jan. 1. The new organization will conduct extensive educational and research work pertaining to all the uses of asphalt and asphaltic oils.

The Asphalt Association was composed of producers and manufacturers but it confined its activities entirely to paving asphalts. The various branches of the asphalt paving industry will now be realigned more effectively in appropriate organizations and already the hot-mix paving contractors have formed an association known as The Asphalt Paving Association, of which Frank J. Silsbee, Engineering Building, Chicago, Ill., is secretary, and Frank O. Hodson, a leading contractor of Gary, Ind., is president.

The officers of The Asphalt Institute who will serve during the brief period until the first annual election in March, are as follows: Joseph S. Helm, Standard Oil Company of New Jersey, New York City, chairman, executive committee; Leroy M. Law, Shell Petroleum Corporation, St. Louis, president; William H. Kershaw, The Texas Company, New York City, vice-president; C. W. Bayliss, Barber Asphalt Company, Philadelphia, vice-president; B. L. Boye, Standard Oil Company of New York, New York City, secretary; Fisher Jones, Mexican Petroleum Corporation, New York City, treasurer, and J. E. Pennybacker, New York City, managing director. The executive, engineering, editorial and technical staff of The Asphalt Association will be taken over by the Institute intact, with Prevost Hubbard, chemical engineer, in charge of research and technology and Clifford S. Lee in charge of public relations. The Asphalt Institute, as did The Asphalt Association, will have its offices for the present at least, at 441 Lexington Ave., New York.

While The Asphalt Institute is authorized to deal with all the uses of asphalt, its major activities during 1930 will be directed toward the improvement and extension of asphalt for city streets and rural highways. In the latter field it is already devoting particular attention to the national program of low-cost farm-to-market roads now being stimulated by such powerful organizations as the American Farm Bureau Federation and many other leading agricultural, civic and motoring organizations. A very pratcical and useful activity by the Institute in connection with low cost roads is a cooperative investigation as to types, specifications, methods and materials it is conducting in cooperation with the U. S. Bureau of Public Roads through committees representing both the Bureau and the Institute, headed by H. S. Fairbank, chief of the Research Committee of the U. S. Bureau of Public Roads, and J. E. Pennybacker, managing director of the Institute. Resurfacing of all types of highways is engaging the concentrated attention of highway engineers and officials in all parts of the United States and since asphalt is ideally adapted for resurfacing all types of pavement at low cost the new organization will give special attention to this field.

Airports are turning to asphalt so extensively as to require the closest attention and cooperation on the part of the asphalt industry in meeting each problem, from the treatment of landing fields with dust-laying oils through various stages to laying the highest type of standard asphalt pavement as exemplified by the very complete Port Columbus airport at Columbus, Ohio.

The Asphalt Institute will also devote considerable attention to the elimination of objectionable and unsound trade practices and to building up a practical and commendable code of trade ethics. It will also cooperate with the U. S. Department of Commerce and other government agencies in the simplified practice field, looking to the elimination of unnecessary grades and the development of sound bases for conducting the business of the Institute. Actual promotion of asphalt in the sense of personal participation in local paving jobs will not be a feature of institute work but will be left to competitive effort by the various producers and contractors interested. The institute's efforts will be directed wholly along sound technical, engineering, educational, scientific and informational lines.

The annual Asphalt Paving Conference, which has become a recognized useful institution as a forum for discussing the practical problems of asphalt paving design, construction, maintenance, and economics, will be continued under the auspices of The Asphalt Institute, but with the cooperation of other organizations, particularly the American Association of Asphalt Technologists. This latter organization, formed seven years ago is made up of technologists serving the states, cities and counties as well as those engaged in the industry, and is headed this year by Prevost Hubbard of The Asphalt Institute, as president, and Charles L. Mullen, of the Milton Hersey Company, Montreal, Que., Canada, as secretary.

The extensive asphalt literature developed by The Asphalt Association has been taken over by The Asphalt Institute, together with all other assets, and distribution of these publications, supplemented by attractive new and additional brochures, manuals and circulars to carry on this phase of the educational work, will be continued on a larger scale than ever before.

Units of Measurement for Street Sanitation

Suggested Forms for Preparing Administative Work Programs and Reporting Actual Costs for Street Cleaning, Refuse Removal and Disposal, with Factors Influencing Unit Costs in Different Cities

THE urgent need of measurement standards by which the results of government could be measured objectively has been realized for a long time. Cloth may be measured by the yard, time by the hour, fuel by the ton, farms by the acre, city lots by the square feet, heat by degrees, etc., but no such objective standards have ever been developed by which the effectiveness of police work, public welfare, and other governmental activities can be ascertained with any degree of certainty.

With a view to meeting this issue, The National Committee on Municipal Standards has been formed by three outstanding organizations interested in the improvement of municipal government: The National Municipal League, The Governmental Research Association and The International City Managers' Association.

At the first meeting of this committee it was decided to select one municipal service in an effort to establish a technique which might be applicable to other services. The service selected was that of street cleaning, refuse removal and disposal. Realizing the necessity of getting the cooperation of the men in the field, the International Association of Street Sanitation Officials was invited to appoint a committee to cooperate in devising units of measurement for this particular service. It was for the use of this committee primarily that a tentative draft of the report was prepared by Clarence E. Ridley, Secretary of the National Committee on Municipal Standards. The matter in this article is taken from this report.

Proposed Units of Measurement for Street Cleaning, Refuse Removal and Refuse Disposal

It would seem that the process of keeping a city clean and free of refuse can logically be separated into three operations, viz: (1) cleaning of streets, which includes merely the accumulation of refuse from the street surface into quantities of sufficient amount to expedite its removal to a disposal point; (2) removal from its source, or point of concentration, of all refuse, including street sweepings, garbage,

(Form 1 S. C.) (Street Cleaning)

Appropriation Classified According to Purchases

a. Personal services	$	
b. Supplies and materials	$	
c. Plant and equipment	$	
Total appropriation for operation	$	(a)
d. Purchase of equipment, etc.	$	
Total cost for street cleaning	$	

Form 1—Street Cleaning

(Form 2 S. C.)

Appropriation Expressed in Terms of the Work to be Done During the Year

_____ great squares cleaned daily	x 365=	_____
_____ " " " six times weekly	x 313=	_____
_____ " " " five " "	x 260=	_____
_____ " " " four " "	x 208=	_____
_____ " " " three " "	x 156=	_____
_____ " " " twice " "	x 104=	_____
_____ " " " weekly	x 52=	_____
_____ " " " twice monthly	x 24=	_____
_____ " " " monthly	x 12=	_____
_____ " " " _____	x __=	_____
_____ " " " _____	x __=	_____
Total estimated number of great squares to be cleaned during the year		(b)
Average estimated Cost of Cleaning per great sq. (a)÷(b)=		

(a) and (b) - These figures should agree with the totals of the monthly estimate figures [illegible] Form 3 S. C.

Form 2—Street Cleaning

(Form 5 S. C.)

City of _____

DAILY STREET CLEANING REPORT

Weather _____ Time. Out____ In____ Date_____ 19____

Equipment used_____ No. of men_____
(Flusher, sweeper, broom, etc.)

Name of Street	Streets Cleaned From	To	Square Yards*
		Total	

(Signed) _____
Operator or Foreman

* This columns to be filled in at office.

Form 5—Street Cleaning

(Form 3 S. C.)

YEARLY STREET CLEANING WORK SHEET

	Method of Cleaning *				Total Number of Great Sqs. (b)	Total Cost (a)	Average Unit Cost Per Great Sq.	Cumulative	
		Great Squares	Unit Cost	Total Cost				Number of Great Sqs.	Total Cost
January	Estimate								
	Actual								
February	Estimate								
	Actual								
December									
Total	Estimate								
	Actual								

(Note: The "Estimate" figures for this sheet may be derived from past records, The "Actual" figures for great squares may be transferred from Form 4 S.C., at the close of each month, and the cost figures obtained from the Controller's office.)

* This Form should include as many similar spaces as there are number of different methods of street cleaning in the particular city.

Form 3—Yearly Street Cleaning Work Sheet

(Form 4 S. C.)

Month of_____ 19_____

MONTHLY REPORT ON STREET CLEANING

Day of Month	Square Yards of Pavement Cleaned by the Various Methods							Total Area Cleaned Expressed in	
								Square Yards	Great Squares
1									
2									
3									
4									
5									
31									
Totals: Sq. Yds:									
Ct. Sqs:									

(Note: The figures for this report may be obtained from Form 5 S. C.)

Form 4—Monthly Report of Street Cleaning

ashes, rubbish, dead animals, leaves, or other refuse, the removal of which is essential to the convenience of the public or the protection of its health; (3) disposal of all such refuse by means of incineration, reduction, filling, dumping at sea, etc.

Purpose of the Plan.—The plan herein proposed has for its purpose: First, the setting up of units of measurement; second, the establishment of a definite and uniform procedure for estimating the amount of work and its cost; and third, the development of a means of financial and administrative control for the following three municipal activities:

1. Street cleaning.
2. Refuse removal.
3. Refuse disposal.

Different Bases of Measuring Governmental Activities.—Activities may be measured in one or more of three ways:

1. On the basis of purchases made, i.e., the cost of labor, supplies, materials, repairs, etc.
2. On the basis of work done, i.e., the area of streets cleaned, the tons of refuse removed and disposed of, etc.
3. On the basis of the result, i.e., the quality of the work done which brings up such questions as, what is a clean street, adequate refuse removal, etc.?

Only the first two are discussed here and suggested forms are submitted which should help in carrying into effect the plan herein presented.

Five Steps in Developing Units of Measurement.—Step 1. Identification of the activity.

Step 2. Determination of a unit of measurement.

Step 3. Determination of factors governing the cost of the activity.

Step 4. Designation of cost in terms of the unit of measurement.

Step 5. Development of an impersonal means of applying the unit of measurement to the activity.

(Form 1 R. D.) (Refuse Disposal)

Appropriation Classified According to Purchases

a. Personal services	$	
b. Supplies and materials		
c. Plant and equipment		
Total appropriation for operation	$	(a)
d. Purchase of equipment, etc.		
Total budget for refuse disposal	$	

Form 1—Refuse Disposal

(Form 2 R. D.)

Appropriation Expressed in Terms of Work to be Done During the Year

Class of Refuse	Estimated Amount in Tons	Method of Disposal (Incineration, reduction, filling, dumping, piggery, etc.)
Ashes		
Catch basin cleanings		
Garbage		
Leaves		
Night soil		
Rubbish		
Street sweepings		
Snow		
Total estimated tons	(b)	

Average estimated cost of refuse disposal per ton (a) ÷ (b) = $_____

(a) and (b) - These figures should agree with the totals of the columns similarly marked -- Form 3 R. D.

Form 2—Refuse Disposal

(Form 6 R.D.) (Refuse Disposal)

City of _____ Date_____19____

DAILY REFUSE DISPOSAL REPORT Weather_____

Method of Disposal_____ Location_____

Record of Refuse Received

Class of Refuse	Delivered by (Truck No.)	Number of Loads	Class of Refuse	Delivered by (Truck No.)	Number of Loads

Summary of Refuse Received

Class_____ Tons_____; Class_____ Tons_____; Class_____ Tons_____

Total tons all classes of refuse:_____

(Signed)_____
Foreman or Superintendent

Form 6—Refuse Disposal

YEARLY REFUSE DISPOSAL WORK SHEET

(Form 3 R. D.)

Month	Class of Refuse / Method of Disposal	Ashes* Quantity in Tons	Unit Cost	Total Cost	Total Quantity in Tons (b)	Total Cost (a)	Average Unit Cost Per Ton	Cumulative Quantity in Tons	Cumulative Cost
January	Estimated								
	Actual								
February	Estimated								
	Actual								
December									
Totals	Estimated								
	Actual								

(Note: The "Estimate" figures may be derived from past records. The "Actual" figures for tons may be transferred from Form 4 R.D. at the close of each month and the cost figures obtained from the controller's office) (a) and (b) - see footnote on previous page.

* Similar headings should be provided for: catch basin cleanings, dead animals, garbage, leaves, night soil, rubbish, street sweepings, and snow.

Form 3—Yearly Refuse Removal Work Sheet

(Form 4 R. D.) Month of_____19____.

MONTHLY REPORT ON REFUSE DISPOSAL

On the Basis of Method of Disposal

Day of Month	Number of Tons Disposed of by the Various Methods of Disposal						Total Tons
1							
2							
3							
4							
5							
31							
Totals							

(Note: The figures for this report may be obtained from Form 6 R. D.)

Form 4—Monthly Report on Refuse Disposal

(Form 5 R. D.) Month of_____19____

MONTHLY REPORT ON REFUSE DISPOSAL

On the Basis of Class of Refuse

Day of Month	Number of Tons of the Various Classes of Refuse Disposed of									Totals
	Ashes	Catch Basin Cleanings	Dead Animals	Garbage	Leaves	Night Soil	Rubbish	Street Sweepings	Snow	
1										
2										
3										
4										
5										
31										
Totals										

(Note: The figures for this report may be obtained from Form 6 R. D.)

Form 5—Monthly Report on Refuse Disposal, on Basis of Class of Refuse

Application of Each Step to the Three Activities.—Step 1. Identification of the activity.

a. Street cleaning: This activity should include the cleaning, irrespective of method, of all paved streets, alleys, sidewalks, or other public ways.

b. Refuse removal: This activity should include the loading and transporting to the disposal point of all refuse irrespective of its source or character, including street sweepings, leaves, snow, garbage, dead animals, night soil, ashes, rubbish, contents of catch basins, etc.

c. Refuse disposal: This activity should include the ultimate disposal of all municipal refuse, whether it be by dumping, burial, pig feeding, incineration, reduction, or other method.

Step 2. Determination of a unit of measurement.

a. Street cleaning: The unit should be the "great square" meaning 10,000 sq. yd. of pavement surface, regardless of whether the full width of the street be actually covered by hand or machine and irrespective of the method used.

b. Refuse femoval: The unit should be the ton-mile which is equivalent to hauling a ton one mile.

c. Refuse disposal: The unit should be the ton.

Step 3. Determination of factors governing the cost of the activity.

The items of cost for each activity should include all items known exactly and which are directly chargeable to that particular activity. Any indirect costs which must be more or less arbitrarily apportioned, such as salaries and expenses connected with the overhead administration of the work must not be included. The items upon which the direct costs shall be based should be reported upon separately under the following headings:

a. Personal services: Salaries and wages.

b. Supplies and material consumed in the work: Brooms, gas, tires, etc.

c. Plant and equipment charges: Repairs, depreciation and interest.

d. Purchase of equipment, machinery, etc.

Step 4. Designation of cost in terms of the unit of measurement.

a. Street cleaning: Cost in cents per great square.

b. Refuse removal: Cost in cents per ton-mile.

c. Refuse disposal: Cost in cents per ton.

Step 5. Development of an impersonal means of applying the unit of measurement to the activity.

a. Street cleaning: The area used as a basis for computing the number of "great squares" cleaned should be the total paved area covered, measured from face to face of curbs and irrespective of what proportion of the total width of the pavement is actually swept, flushed, or cleaned by any other method.

b. Refuse removal: The tonnage should be computed by cubical content of truck bodies and by weighing a sufficient number of loads to afford a reliable basis for such computation. The mileage will be based on the length of the route traversed from the receiving point to the disposal point. The product of the two will give the number of ton-miles.

c. Refuse disposal: The tonnage for this purpose may be computed in a manner similar to the method stated under "refuse removal."

(Form 1 R. R.) (Refuse Removal)

Appropriation Classified According to Purchases

a. Personal services	$
b. Supplies and materials	$
c. Plant and equipment	$
Total appropriation for operation	$ (a)
d. Purchase of equipment, etc.	$
Total budget for refuse removal	$

(a) This figure should agree with the total of the column similarly marked on Par

Form 1—Refuse Removal

(Form 2 R. R.) (Refuse Removal)

Appropriation Expressed in Terms of the Work to be Done During the Year

Class of Refuse	Estimated Amount in Tons	Frequency of Collection
Ashes		
Catch basin cleanings		
Dead Animals		
Garbage		
Leaves		
Night soil		
Rubbish		
Street sweepings		
Snow		
Total estimated tons	(b)	

Average estimated cost of refuse removal per ton (a) ÷ (b) = $

(a) This figure is obtained from Form 1 R. R. on previous page.

(b) This figure should agree with the total of the column similarly marked on page 13.

Form 2—Refuse Disposal

(Form 3 R. R.)

YEARLY REFUSE REMOVAL WORK SHEET

Month	Class of Refuse / Estimated Haulage Distance in Miles	Ashes* Tons	Ton-Miles	Unit Cost	Total Cost		Total Tons (b)	Total Ton-Miles	Total Cost (a)	Average Unit Cost Per Ton-Mile	Cumulative Quantity in Ton-Miles	Cumulative Total
January	Estimate											
	Actual											
February	Estimate											
	Actual											
December												
Total	Estimate											
	Actual											

(Note: The "Estimate" figures may be derived from past records. The "Actual" figures for tons and ton-miles may be transferred from Form 4 R. R. at the close of each month and the cost figures obtained from the Controller's office.)
(a) and (b) - see footnote on previous pages

*Similar headings should be provided for: Catch basin cleanings, dead animals, garbage, leaves, night soil, rubbish, street sweepings and snow.

Form 3—Yearly Refuse Removal Work Sheet

(Form 4 R. R.) Month of _____ 19___

MONTHLY REPORT OF REFUSE REMOVAL

Day of Month	Ashes* Tons	Ton-Miles	Total Refuse Removed Expressed in Tons	Ton-Miles	Remarks
1					
2					
3					
4					
5					
31					
Totals					

(Note: The figures for this report may be obtained from Form 5 R. R.

* Similar headings should be provided for: Catch basin cleanings, dead animals; garbage, leaves, night soil, rubbish, street sweepings, and snow.

Form 4—Refuse Removal

(Form 5. R. R.) (Refuse Removal)

Truck No. _____ City of _____ Date _____ 19___

Capacity _____ Cu. Yds. DAILY REFUSE REMOVAL REPORT Weather _____

Class of Refuse Handled	No. of Loads	Hrs. Spent on Each Class	Haulage Distance in Miles	Total Amount Hauled Cu. Yds.	Tons	Ton Miles	Remarks
Ashes							
Catch basin cleanings							
Dead animals							
Garbage							
Leaves							
Night Soil							
Rubbish							
Street sweepings							
Snow							
Total							

(Signed) _____
Truck Driver or Foreman

Form 5—Refuse Removal

Factors to Be Considered in Comparing Unit Costs Between Different Cities

A. Street Cleaning

I. Factors Subject to Governmental Control.
1. Factors within the control of the street cleaning unit.
   a. Organization and procedure.
   b. Time of doing the work (to a limited extent only, for traffic conditions may govern).
   c. Methods and equipment used (to a limited extent, for grade of streets, availability of water and other conditions may govern).
2. Factors outside the control of the street cleaning unit.
   a. Types of pavement and state of repairs.
   b. Character and amount of traffic.
   c. Type of district, wholesale, retail, residence, etc.
   d. Character of street refuse.
   e. Condition of intersecting streets.
   f. Character and density of population adjacent to streets.
   g. Kind and number of trees adjacent to streets.
   h. Legislation governing the sweeping and dumping of refuse on to the streets and the enforcement thereof.
   i. Standard of cleanliness desired.
   j. Local wage scale (to a limited extent).

II. Factors Not Subject to Governmental Control.
1. Climatic conditions (snowfall, rainfall).
2. Grade of streets (to a limited extent only).

B. Refuse Removal

I. Factors Subject to Governmental Control.
1. Factors within the control of the refuse removal unit.
   a. Organization and procedure.
   b. Methods and equipment used (to a limited extent for condition of streets and degree of separation of different classes of refuse may govern).
   c. Transfer of refuse between point of collection and delivery point.
2. Factors outside the control of refuse removal unit.
   a. Haulage distance.
   b. Quantity of refuse at points of collection.
   c. Type and capacity of containers.
   d. Whether house refuse is collected from curb or from premises.
   e. Degree of separation of different classes of refuse.
   f. Condition of streets.
   g. Density of traffic over haulage route.
   h. Standard of sanitation observed in collection and hauling.
   i. Local wage scale(to a limited extent).

II. Factors Not Subject to Governmental Control.
1. Climatic conditions.
2. Grade of streets (to a limited extent).
3. Distance refuse must be hauled to point of disposal (to a limited extent only).

C. Refuse Disposal

I. Factors Subject to Governmental Control.
1. Factors within the control of the refuse disposal unit.
   a. Organization and procedure.
2. Factors outside the control of the refuse disposal unit.
   a. Degree of necessity for suppressing odors.
   b. Proportion of different classes of refuse.
   c. Methods of disposal (to a limited extent only, because physical characteristics of the area will have some bearing).
   d. Local wage rates (to a limited extent).

Revised A. S. T. M. Specifications for Paving Brick

Reviewed by F. H. Jackson, Senior Engineer of Tests, U. S. Bureau of Public Roads

During the past two years the Committee on Brick of the American Society for Testing Materials has been engaged in revising the Standard Specifications for Paving Brick which were originally promulgated in 1915. The old standard which provided that paving brick in order to be acceptable must pass the standard rattler test as well as certain requirements as to visual inspection has proved in general eminently satisfactory to both the buyer and seller of this commodity. In the course of time, however, certain changes as to form and arrangement as well as certain detailed changes in substance have become necessary in order, in the first case, to bring the standard in line with the regulations of the society as to form and, in the second case, in order to keep pace with changing practice relative to the size of brick used for pavement construction. This review will be concerned chiefly with the changes in substance which have been made together with the reasons therefor.

At the time the original standard was issued, most of the brick used for pavements were of the so-called "block" size; that is, 3½ by 4 by 8½ in. There was consequently no need to take the size or volume of the brick into consideration when interpreting the results of the rattler test. Within recent years, however, there has been introduced and used in this country paving brick considerably smaller than the old "block" size, sizes as small as 3 by 3½ by 8½ in. now being recognized. Inasmuch as the percentage of loss in the abrasion test will be affected by the size or volume as well as by the quality of the brick it became necessary to modify the old standard either by providing a series of correction factors whereby the loss by abrasion on any size brick could be corrected so as to show the percentage of loss which would have been obtained by the brick had it been of standard size or by inserting in the specification itself maximum permissible rattler losses of each size recognized. The first revision of the specification made in 1928 provided a series of correction factors which were derived from test data showing the effect of size of brick upon the percentage of loss. Corrections made in this manner, however, did not prove entirely satisfactory to all concerned and it was finally decided by the committee to discard this method in favor of the method of indicating directly the maximum permissible rattler loss for each size provided the manufacturers would agree to reduce the maximum permissible tolerance in length of brick from ½ in. to ¼ in. so as to control more accurately the actual size of brick marketed under a given nominal size. This the manufacturers agreed to do and the present tentative specification has been prepared on this basis.

The present tentative specification recommended the use of the various sizes and types of paving recognized by the Permanent Committee on Simplification of Varieties and Standards for Paving Brick of the U. S. Department of Commerce as approved in 1929 wherever possible and in accordance therewith provides for four nominal sizes of brick, with corresponding rattler losses as follows:

Size of Brick		
Transverse Dimensions Inches	Length Inches	Loss in Rattler Test Per Cent
2½x4	8½	26
3 x3½	8½	26
3 x4	8½	24
3½x4	8½	22

The method of making the rattler test as well as the various items dealing with acceptance under visual inspection remain unchanged in the new specification. The requirements governing sampling have, however, been considerably modified, chiefly in the interests of simplification and clarification.

It is confidently expected that the new specification will prove as acceptable to both the producer and consumer of paving brick as the old standard and that it will, in addition, satisfactorily care for the question of size of brick as affecting the rattler loss.

Concrete Pavement Core Drill Records in Pennsylvania.—Following is the record for the jobs of 60 contractors drilled in 1929, covering 101 miles of pavement:

Number of cores removed	1,257
Edge measurements	1,178
Deficient, ¼ to ½ in.	6
Deficient more than ½ in.	2
Exact thickness or greater	1,249

Traffic Control Developments in 1929

Encouraging progress in the reduction of America's two billion dollar a year bill for traffic congestion and accidents is evident in a review of the year's developments in traffic control, according to Miller McClintock, director of the Albert Russel Erskine Bureau for Street Traffic Research in Harvard University.

Developments of the past year, he finds, reveal a growing determination to relieve congestion and increase the efficiency of the city streets in order to secure a greater return on the tremendous investment they represent. Substantial progress in this direction is being made through the adoption of sound engineering methods of traffic control.

The past year has seen a notable increase in traffic mindedness among public officials and others affected by the problems of street traffic congestion. Cities all over the country are recognizing that traffic is primarily an engineering problem not to be solved by temporary application of traffic cure-alls and panaceas. As a result there has been less dabbling and more sound engineering progress in traffic control in 1929 than ever before.

Traffic Signals Improve.—There has been a definite tendency to call a halt to the over-regulation of traffic through haphazard installation and operation of stop and go lights and other signals. Unnecessary and poorly timed traffic lights are the source of a great deal of congestion and delay, due to the frequently neglected fact that such lights stop traffic as well as pass it along.

Pennsylvania, New Jersey, Massachusetts, and the city of Chicago have taken steps during the past year to establish scientific standards for signal light control in order to insure that future installations shall aid rather than hinder traffic movement. There has also been an encouraging movement throughout the country for a better use and timing of existing signals.

The outstanding development of the year in this respect is the formulation of a uniform signal code by the Commonwealth of Massachusetts, governing the installation and operation of every traffic light in the state.

The new code establishes uniform signals throughout the state, and will eliminate the delays and annoyances caused by unnecessary stop lights by requiring that actual traffic counts show a sufficient volume of traffic to warrant an installation by local authorities.

The greatest innovation of the year in signal control is the automatic traffic actuated device. Several types of these subject traffic to minimum delays at intersections where cross traffic is not heavy enough to justify the conventional type of regularly alternating stop and go light.

"No Parking" Successful.—Parking is still one of the most mooted aspects of the traffic problem. The success of the "no parking" rule in the Chicago "Loop" district has led to a more open minded attitude in regard to prohibited parking by business men and motorists alike.

The result is a more widespread recognition that street storage of motor vehicles must be limited or entirely abolished when it reaches such a stage as to interfere seriously with traffic movement.

This had led to an appreciation of the necessity for off-street storage facilities in big down town garages and for the provision of garage space in future skyscrapers.

No Pedestrian Control.—There has been no progress whatever in pedestrian control. Until last year the tendency seemed to be toward greater control of pedestrian traffic. During 1929, however, no successful pedestrian control system was installed. Los Angeles still remains the best example of any large city which has successfully attempted to control this important source of accidents and congestion.

Improved Highway Design.—Wide recognition of the utility of separated grade intersections for heavily traveled highways promises to exert a far reaching effect in increasing the speed and safety of travel on our principal highways. Conflicts and delays at the intersection of such highways materially reduce the capacity of each route. Separating the intersections to permit one traffic stream to flow over or under the other permits continuous movement and restores the efficiency for which the highway was designed.

The Westchester Park System in New York is an outstanding example of the use of separated grades at intersections. Another is the New Jersey approach to the Holland vehicular tunnel beneath the Hudson River. Chicago's outer drive along the lake shore has several such intersections, which aid motorists to drive to the heart of the city at sustained speeds of 35 miles and 40 miles an hour.

The West Side elevated highway in New York City and well defined plans for similar elevated express highways in Boston and Chicago indicate clearly that highways are "going rapid transit" in cities as well as in the country.

The past year has seen a definite recognition in the largest cities of the necessity for fast elevated express highways. Plans already projected suggest that a speed of sixty miles an hour with greater safety is no longer a visionary development in city traffic relief.

Uniform Traffic Rules.—Slow but encouraging progress has been made toward the adoption of the Uniform Vehicle Code and the Model Municipal Traffic Ordinance sponsored by the National Conference on Street and Highway Safety. Secretary of Commerce Lamont, who is taking an active and progressive interest in furthering the program initiated by President Hoover, recently appointed a technical committee to undertake a revision of the Model Municipal Ordinance in order to meet new conditions which have developed in the constantly changing pattern of city traffic.

The municipal ordinance has been adopted substantially as recommended in Indianapolis, Providence, and several other cities. The city traffic ordinances of Chicago, Boston, San Francisco, Los Angeles, and a number of smaller cities are based in part on the model code.

Twenty-three states thus far have enacted legislation based in the Uniform Vehicle Code. Of these, twelve have adopted one or more of the four acts in the complete code.

Despite this progress, the lack of basically uniform traffic regulations is still a major problem throughout the United States.

A number of states have shown a definite and altogether proper tendency to centralize responsibility for traffic control to the exclusion of action by local authorities. This is evident in New Jersey, Wisconsin, California, Michigan, New York and Massachusetts.

There is hardly a city of any size in the country which is not aware of the seriousness of the delays, dangers, inconveniences and costs of traffic congestion. Cities are learning, too, that in nearly every case facts are available which with proper engineering study disclose methods of bringing substantial reductions in congestion.

The traffic problem, touching as it does every street user and intimately affecting every element of the population, is a complicated combination of psychology, engineering, economics, and many other factors. It is not a problem which can be solved by any single panacea, but there is no doubt that the coming year will see substantial progress in increasing the efficiency of our streets and highways.

Civil Service Examinations for Engineers.—The U. S. Civil Service Commission, Washington, D. C., has announced open competition examinations for the following positions: Associate engineer, $3,200 to $3,700 per year; assistant engineer, $2,600 to $3,100 a year. Eligibles are especially desired for the supervising architect's office. Examinations also are to be held for hydraulic engineers at $3,800 to $4,400 per year, associate hydraulic engineers at $3,200 to $3,700 and assistant hydraulic engineers at $2,600 to $3,100. These examinations are to fill vacancies in the Engineer Department at Large, War Department.

The Maintenance of County Highways

How a Small County in Illinois Secures Efficiency and Economy in Maintaining Its County Road System

By LEON F. WALKER

County Superintendent of Highways, Crawford County, Illinois

WHEN highway maintenance has been freed from political control, the responsibility for efficient and economical service then rests upon the engineer. And there are certain principles and rules which must be followed if the public is to receive a maximum return on their tax investment. The one principle which should be constantly kept in mind by officials responsible for the expenditure of road funds is that their first and only duty is to serve the traveling public to the best of their ability with benefit to all and special favor to none. The first rule based upon this principle is that traffic should be the governing factor in the expenditure of all money for maintaining roads in various sections of the county. Another rule is that all employees should be selected for their ability to do the work required, and that they should be retained in their positions as long as they render satisfactory service to the public. And another rule is that all work done by contract should be awarded to the lowest responsible bidder, if he is qualified to do the work. If the foregoing principle and rules based thereon are faithfully adhered to, and, if the engineer responsible for the direction and supervision of the work is competent, every taxpayer in the county will receive a fair and legitimate return on his investment.

Crawford County, Illinois.—That work can be carried on in accordance with these rules has been successfully demonstrated in Crawford County, Illinois. Crawford County is not a large county, neither does it possess an overabundance of wealth, and its road problems are no different from those encountered in hundreds of other counties in the United States. The county is located in the southern part of the state, and is bounded on the east by the Wabash River. It lies 22 miles north and south, with an average width of 20 miles east and west. The population is about 23,000. Robinson, the county seat, with a population of 5,000, is located at the center of the county. The main industries of the county are farming and the production of oil. Gravel deposits are scattered along the east side of the county, providing a plentiful supply of surface material for road improvement and maintenance.

There is a total of 820 miles of public road in Crawford County. The state maintains 45 miles, the county 90 miles, and the townships 685 miles. The county maintains 86 miles of gravel road and 14 miles of earth road; the townships maintain 230 miles of gravel road and 455 miles of earth road.

County Government and Road Tax.—Crawford County is governed by a board of 11 supervisors, one elected in each township of the county for a term of two years, six being elected one year and five the following year. The board of supervisors appoints a superintendent of highways with the approval of the state highway department for a term of six years. The superintendent of highways directs and supervises the construction and maintenance of roads and bridges in the county in accordance with the wishes of a road and bridge committee made up of five members of the board of supervisors and appointed by the chairman of the board. A property tax is levied by the board of supervisors each year for the maintenance and improvement of county roads. The tax rate for this purpose is limited by statute. The tax levied last year amounted to the sum of $35,000.

Equipment Storage Shed of Crawford County

Program and Budget.—With a definite sum of money available for the year's work, the first step is to prepare a plan or budget for spending the money in the most economical way with the greatest benefit to the traveling public. In Crawford County the maintenance work is classified into the following items: Equipment, patrolling, resurfacing, grading, bridges. After studying the cost records of previous years and visualizing the needs of the coming year, the road fund was divided last year as follows: Equipment, $2,000; patrolling, $7,000; resurfacing, $17,000; grading, $1,000; bridges, $8,000.

Equipment.—In order to properly maintain roads, the county must own the necessary machinery and tools. What equipment is necessary must be determined by the engineer from his own experience and the experience of others. It will be found most economical to buy equipment from reliable and well established concerns. The cheapest equipment is not always the best or most economical to buy. Crawford County owns a 5-ton tractor of the crawler type, an 8-ft. grader, a heavy seven blade maintainer, seventeen patrol graders, twenty-one drags, and a supply of scrapers and smaller tools.

Once the machinery is bought, economical and efficient service depends upon good care. The first requirement for the proper care of road equipment is a storage shed where machinery and tools can be kept out of the weather while not in use on the road. Crawford County owns an equipment shed located just outside the city limits of Robinson. This shed is a wooden building measuring 60 ft. long and 26 ft. wide, with concrete foundation, gravel floor, and galvanized metal roof. The foundation extends 2 ft. below the ground elevation and 1 ft. above. The shed is provided with a 20-ft. opening with two sliding doors at the front end and a 12-ft opening with a single sliding door at the rear end. The building has twelve windows, and is equipped with electric lights. A 280-gal. gasoline tank is buried on the outside of the building with a pump on the inside close to the front entrance. This equipment shed complete with three coats of paint was built at a cost of $1,000.

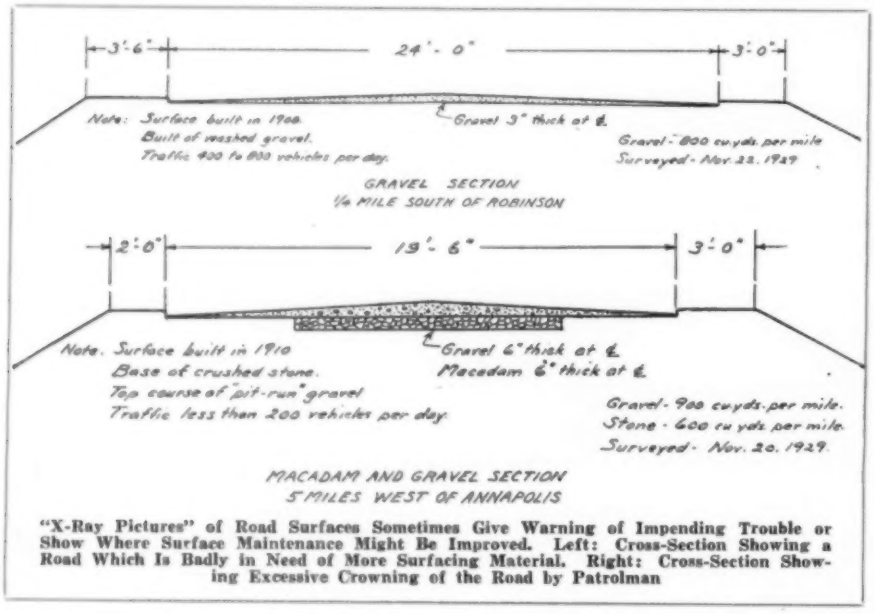
The next important requirement is the hiring of reliable and experienced employees to operate the machinery. It is poor policy to attempt to save money by employing inexperienced and unreliable men at a low wage to operate costly machinery. An inexperienced or careless tractor operator employed at a low wage can cost the county much more than a good operator employed at a higher wage. Good service should always be rewarded with good wages.

Other important requirements are the cleaning, painting, and greasing of equipment, and prompt attention to repair work. All machinery should be kept well greased and properly lubricated while in operation, and during the winter months it shoud be thoroughly cleaned and painted. All repairs should be made promptly when needed. Any delay in attending to repair work should be avoided, as delay may mean more costly repairs.

The portion of the road fund set aside for equipment covers the following items of expense: insurance on storage shed and contents, upkeep of shed, depreciation on all machinery and tools,

all repair work, all new parts, and the purchase of additional equipment.

Surface Maintenance.—Surface maintenance is carried on by a patrol system supplemented by a heavy tractor-drawn maintainer which covers all patrol sections at regular intervals. Twenty-one patrolmen are employed by the county on an hourly basis for blading and dragging the surface, mowing shoulders, cutting weeds and other vegetation, and making minor repairs on the road. Patrol sections average six miles in length on gravel roads and two miles in length on earth roads. All patrolmen are farmers living directly on or within one mile of the sections which they patrol. Each patrolman is equipped with a patrol grader, drag, and shovel. He is required to furnish his own team, and he is held responsible for keeping his equipment in serviceable condition.



"X-Ray Pictures" of Road Surfaces Sometimes Give Warning of Impending Trouble or Show Where Surface Maintenance Might Be Improved. Left: Cross-Section Showing a Road Which Is Badly in Need of More Surfacing Material. Right: Cross-Section Showing Excessive Crowning of the Road by Patrolman

Instructions issued to the patrolmen when they are appointed are as follows:

You have been appointed patrolman on the section of county road from.....to .....to begin work on.....19.....

This section of road will be under your care, and you are responsible for its condition at all times.

Equipment: The patrolman is responsible for all equipment assigned to him, and this equipment should be kept in good repair. Equipment is to be used for work on county roads only, and must not be lent to any person for any other work without permission from the superintendent. The patrolman should notify the superintendent when new parts are needed. Minor repairs should be taken care of by the patrolman. New grader and drag blades may always be obtained at the county shed.

Dragging: A gravel road should be bladed or dragged preferably after a rain or thaw, but it must also be bladed at regular intervals during dry weather. Always use the patrol grader in preference to the drag except during the winter months when the road is too soft to use the grader. During dry weather blade the gravel often enough to keep it evenly distributed over the surface and to prevent it from being lost in the side ditches. With the amount of funds available, it is necessary to place a limit upon the frequency with which a road may be bladed or dragged. Each patrolman will receive special instructions from time to time on the frequency with which he may be permitted to blade or drag the surface.

Mowing: The shoulders should be mowed with a mowing machine twice during the summer. Weeds and other vegetation should be kept cut around bridges and culverts.

Other Work: Bridges, culverts, drains, and ditches should be kept open and free from debris at all times. Special attention should be given to the condition of bridge floors. Any bridge or culvert which is found in a dangerous condition should be reported to the superintendent at once. If a portion of the road should become impassable during the winter months, the superintendent should be notified at once.

Work Report: Postal cards are furnished by the county for the use of patrolmen in sending in reports of their work. The date on which the work was done, and the hours between which it was done must be given in order to receive payment. Always describe the nature of the work, and the number of horses or men used.

Payment for work:

	Cents Per Hour
Blading with patrol grader	50
Dragging with drag (2 horses)	50
Dragging with drag (3 horses)	65
Dragging with drag (4 horses)	80
Single hand	30
Team with man	50
Mowing and furnishing mower	75

(Broken parts paid for by county.)

Expenses: When telephoning messages to the superintendent, order the charge reversed. Pay for minor repairs on grader and drag, obtain a receipt, and send in receitp with work report. When a car is used to put up road signs, send in the number of miles traveled as well as the time.

Requirements: A patrolman's appointment will continue as long as he shows an interest in the care of the road, does his work well, and follows the instructions of the superintendent, unless some change is deemed necessary for better maintenance of the road. It is not expected that a patrolman will be able to go out on the road every single time that it needs blading or dragging, but it is expected that he will try to arrange his other work so that he can go out on the road most of the time when it needs attention, and give the road a reasonable amount of care. When there is any doubt about how the work should be done, ask the superintendent.

Safety: Do not neglect dangerous washouts on the road. If you cannot repair them at once, put up some kind of warning sign.

Patrolmen Not Removed for Political Reasons.—The patrolmen in Crawford County are not selected or changed for political reasons, and they retain their positions as long as they render satisfactory service. New members are elected to the board of supervisors each year, but the patrolmen in townships where new supervisors are elected continue to hold their positions regardless of these changes. Several attempts have been made to change patrolmen for solely political reasons, but all attempts of this kind have met with failure. The patrolman knows that to retain his position he must render satisfactory service, and he knows also that, if he fails to render satisfactory service, he will not be able to hold his position through political influence. A man who is hired through political influence will have very little incentive to do more than ordinary work, because he knows that his position does not depend on the quality of the work he does, and because he also knows that he will lose his position when the time comes regardless of how well he performs his work. In order to obtain efficient service from patrolmen, they must be given to understand that the length of their appointment depends upon their honesty, their obedience to instructions, and the quality of their work.

Operations of Tractor-Maintenance.—With the exception of about three months in the winter and the time required for cleaning side ditches in the summer, the heavy maintainer is in daily operation. The tractor and maintainer are both operated by the same man. The maintainer weighs about 3,700 lb., is 22 ft. long, and has seven blades and a scarifier. It drags 10 ft. of surface or half the width of the traveled way. It travels an average of from 18 to 20 miles per 9-hour day, covering a 9 or 10 mile section of road. By the use of this maintainer the road surface is freed of all bumps, holes, and corrugations, and is leveled smooth once in every two weeks. In the meantime, the patrolmen keep the loose material spread over the surface with patrol graders. In the winter months during the freezing and thawing weather the heavy maintainer cannot be used, and the roads are maintained altogether by the patrolmen with horse-drawn drags.

The tractor operator is also furnished with postal cards on which he sends in daily reports of his work. On these cards he shows the date, the patrol sections on which work was done, the approximate number of miles traveled, the number of gallons of gasoline put in the tractor that day, change of motor oil, and any other remarks thought necessary. In this way an accurate record is kept of the work accomplished by the maintainer, and its daily progress can be followed at the office.

The portion of the road fund set aside for patrolling or surface maintenance covers the following items of expense: wages of patrolmen, wages of tractor operator, and gasoline, oil, and grease for the tractor.

Grading.—Each summer when the ground is dry, the 8-ft. grader is used to open and clean side ditches on the gravel roads and to reshape the earth roads. In order to do this work satisfactorily and economically, an experienced grader man must be employed, from year to year. After the grader work has been completed, the patrolmen open up all places in the side ditches which were not accessible to the grader, and clean out around all bridges and culverts.

The portion of the road fund set aside for grading covers the following items of expense: wages of tractor operator, wages of grader man, and gasoline, oil, and grease for the tractor.

Resurfacing.—All resurfacing work is done by contract. The work is advertised, sealed bids are received, and the contracts are awarded to the lowest responsible bidders. In this way the work is done at the lowest possible cost. Contracts are awarded during the winter, and the new material is added as soon as the roads are suitable to haul over in the spring. Gravel is put on heavier where the surface has shown weak spots duing the winter, and is spread uniformly elsewhere. The amount of gravel added on various sections of road is proportioned as nearly as possible to the amount of traffic wear.

A traffic survey was made, extensive enough, to give the approximate amount of traffic on all sections of road in the county. Leading into Robinson is a road ½ mile in length which carries from 1,000 to 1,500 vehicles per day. There are 19 miles of road which carry from 400 to 800 vehicles per day, 22½ miles which carry from 200 to 400 vehicles per day, and 34 miles which carry less than 200 vehicles per day. With $17,000 available for resurfacing work, it is possible to add 300 cu. yd. of material per mile every year to the section of road carrying from 1,000 to 1,500 vehicles per day, 200 yd. per mile every year to roads carrying from 400 to 800 vehicles per day, 200 yd. per mile every two years to roads carrying from 200 to 400 vehicles per day, and 200 yd. per mile every three years to roads carrying less than 200 vehicles per day.

Gravel is obtained from pits located on the east side of the county along the Wabash River. Two grades of gravel are used. One grade of material is taken from the banks and contains an excess of sand, but it possesses an excellent natural binder. The other grade is pumped from below the water level and is screened to remove the excess sand. The screened material is well graded, but it is clean and has no binder. Gravel is always hauled from the nearest pit unless a better quality of gravel can be obtained with a little longer haul.

To secure efficiency and economy in resurfacing work the chief requirement is proper inspection both of the material and of the work. An inspector is kept at the pit at all times while hauling is going on to make sure that every load of material going out on the road passes the required specifications. Where screened gravel is used, not more than 25 per cent of the material is permitted to pass through a No. 8 sieve. Not less than 95 per cent of the material used passes a one inch sieve. The pit inspector also measures and records the capacities of all truck beds. The regular patrolmen act as inspectors on the road when resurfacing work is being done on their sections. The patrolmen are used as inspectors on the road because they know better than anyone else the condition of the surface on their particular sections. The patrolmen supervise the placing of the gravel and keep a record of the number of loads hauled by each truck.

The portion of the road fund set aside for resurfacing covers the following items of expense: cost of material, cost of hauling and spreading by contractors, and cost of inspection.

Bridges.—All bridge work of any size is done by contract. The work is advertised, sealed bids are received, and the work is awarded to the lowest responsible bidders. There are still many old bridges and culverts in the county which must be repaired or replaced—narrow bridges, bridges with insecure foundations, bridges built of poor concrete with little or no reinforcing steel, and bridges with insufficient waterway. This work can be governed only to a slight extent by traffic. The only fair way to take care of bridge construction and repair is to keep a record of the condition of all drainage structures in the county, and to select for improve- of location. A bridge or culvert which are in the worst condition regardless of location. A bridge o r culvedt which is in a dangerous condition should have precedence over a bridge or culvert which is inadequate for drainage purposes. When two or more structures are in practically the same kind of condition, the structure carrying the most traffic should have first consideration.

In Crawford County a record is kept at the office of all bridges and culverts on each section of road. This record shows the location to the nearest one-tenth of a mile, the type of structure, the span, clearance, height, and roadway, and the condition of the structure. Bridges and culverts are inspected each fall, and the record brought up to date. It is then a comparatively simple matter to select the bridge work for the coming year.

All construction work should have proper inspection, and all material used in a structure should be tested and found satisfactory before being used.

The portion of the road fund set aside for bridges covers all items of expense connected with the construction and re pair of bridges and culverts including inspection.

Investigation and Study.—In order to

Name of Patrolman Raymond Wilson
Patrol Section No. 14

DATE	HOURS A.M.		HOURS P.M.		NATURE OF WORK DONE
7/8/29	7	12	1	5	Patrol grader
7/9/29	7	12			Single Hand - repairing bridge
7/11/29	7	12	1	5	Patrol grader
7/15/29	7	12	1	5	" "

Remarks:

DAILY TRACTOR REPORT

Date 10/5/29

Patrol Sections #13 + #14

Grading hours miles

Dragging 9 hours 18 miles

Amount of gasoline 20 gallons

Grease and oil changed oil

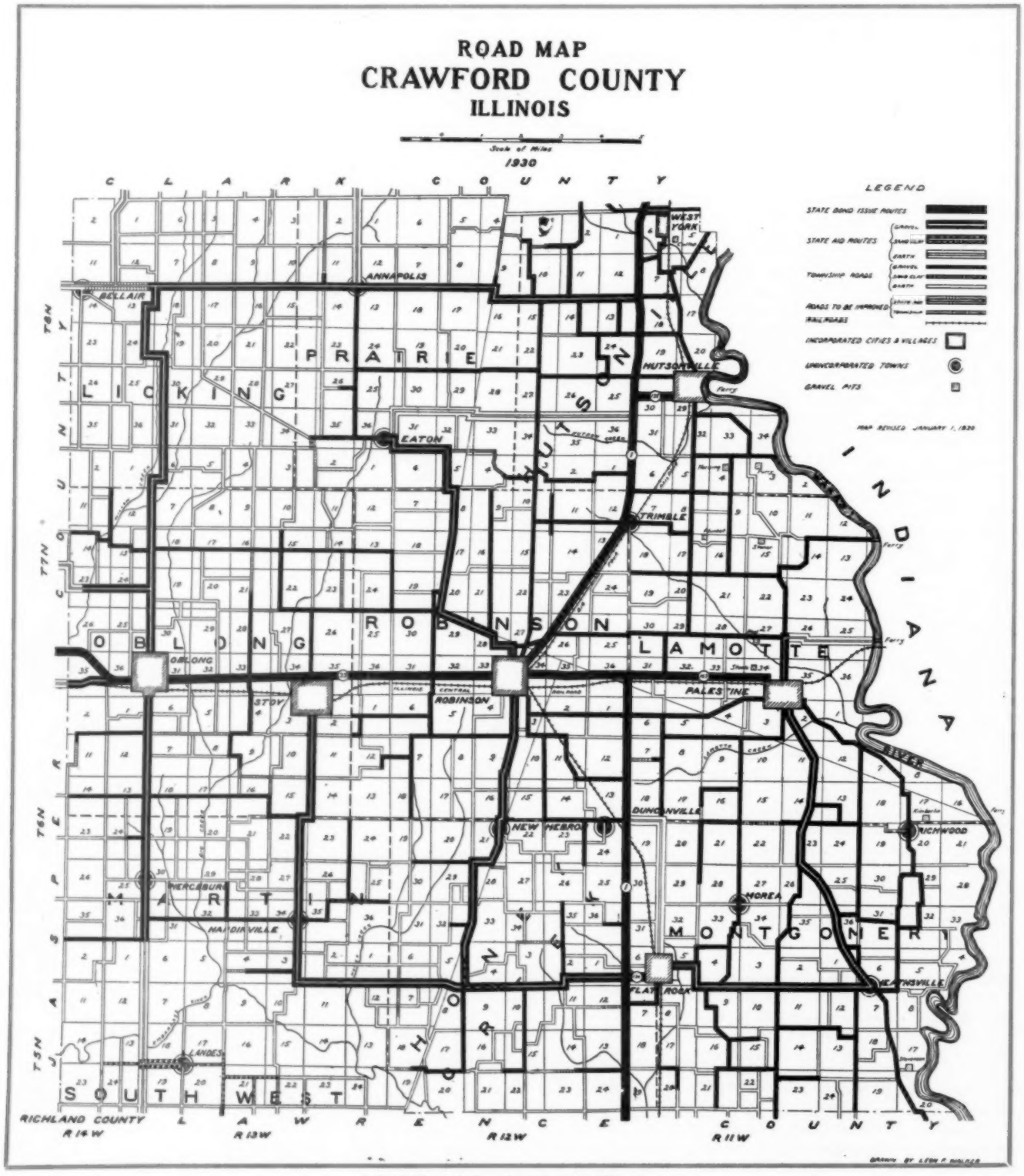
Remarks

order more oil

Report Cards Used by Patrolmen and Tractor Operator

secure maximum efficiency and economy in highway maintenance, the engineer must be continually seeking new and better methods of carrying on the work. He should study the methods being used by others, and conduct investigations and experiments of his own. Interesting and useful information has been obtained in Crawford County from investigation of existing road surfaces. Cross-sections of the highway have been taken at various locations, and, by digging holes to the bottom of the surfacing material, these cross-sections are made to show the thickness, width and shape of the surface. Sections have been found on the more heavily traveled roads where the surface has been worn down to a thickness of only 3 in. Most of the sections showed that the patrolmen were blading the gravel in such a way as to produce an excessive crown. Accurate and definite information such as this enables the engineer to intelligently carry on the work and devise any needed remedies.

Cost Records.—Accurate cost records are a necessary requirement for the economical planning of the work from year to year. A study of the preceding year's expenses will show how the money may be spent more economically during the coming year. Records



Road Map of Crawford County, Illinois

should be made as simple as possible, all unimportant information being disregarded.

In Crawford County the money is paid out once every month by the board of supervisors, and the records are therefore kept on a monthly basis. The expenses are totaled each month under the headings of Equipment, Patrolling, Resurfacing, Grading, and Bridges, and the balance is shown for each item of work. A list of all equipment is brought up to date every month, giving a description of each piece, the date of purchase, the cost, and the name of the person who is responsible for its care. Another list is kept of all new parts and repairs. A monthly record is kept for each patrolman, showing the hours worked and the pay received. A monthly record is kept showing the number of yards of gravel added to each section of road. Other information on resurfacing work is kept on file with the contracts. A monthly record is kept of work done by the tractor, showing the number of hours in operation with the maintainer, and the number of hours in operation with the grader. A list is kept of the amount of gasoline, oil, and grease, purchased for the tractor. All information connected with bridge work is kept on file with the contracts.

Contact With the Public.—To carry on maintenance work efficiently and economically, the engineer must not be influenced by incompetent advice and unjust criticism. It seems to be in the nature of some persons to want to continually advise and criticise the actions of others and especially of those who hold public office. A man whose only contact with a highway has been to travel over it sometimes considers that he knows more about its construction and maintenance than the engineer who has made highway engineering his life profession. The engineer cannot afford to be influenced by the advice of such a man, regardless of his standing in the community. When in doubt concerning maintenance problems, the engineer should seek advice from reliable and experienced men in his own profession.

The work of public officials is criticised for many different reasons, and, very often, criticism arises from ulterior motives. Some criticism is deserved, and such criticism should be promptly heeded. But, if an engineer is competent and is administering the work to the best of his ability, most criticism will be found to be undeserved and unjust. One kind of criticism comes from the man already mentioned, the man who thinks he knows how the work should be done and discovers that it is not being done in accordance with his ideas. Another form of criticism comes from the man who does not understand the facts in the case, the man who is misinformed, or the man who is misled by inaccurate information. And a large part of all criticism comes from the man whose motives arise from personal animosity, envy, or selfishness. The writer has listened to scores of complaints on the work of patrolmen, and he has yet to hear one that has not been actuated by selfish motives. In every case the complaining party wished to have the patrolman removed either because of a personal grudge or because he sought the position for himself. The engineer should always be alert in refusing to be influenced by criticism of the work of employees unless actual evidence or proof is forthcoming.

The highway official comes into contact with incompetent advice and unjust criticism continually, but he cannot render efficient and economical service if he allows himself to be influenced by such advice and criticism. No official can perform his work to the satisfaction of all persons in the community, but he can, and should be, courteous, patient, and considerate in all of his dealings with the public. And, above all, he should assure himself that he is carrying on his work in accordance with approved methods efficiently and economically.

Conclusion.—In conclusion it may be said that efficiency and economy in the maintenance of county highways depend upon, (1) freedom from political interference and control, (2) appointment of trained and experienced engineers for directing and supervising the work, and (3) willingness on the part of highway officials to serve the public welfare unselfishly, impartially, and to the best of their ability.

Street Oiling in St. Louis, Mo.

Some interesting information in dust prevention on unpaved streets by oiling was given by J. M. Slater, Street Commissioner of St. Louis, Mo., in a paper presented at the 10th (1929), annual convention of the International Association of Street Sanitation Officials. We quote as follows:

Since 1927 dust prevention has been carried on entirely by the oiling of telford macadam and unmade streets.

At the beginning of each year of oiling, we grade and surface carefully the road beds, clean out the ditches in order to insure good drainage and remove all the surplus dirt before oiling.

We have found that the best results are obtained by using an oil of medium gravity inasmuch as a very light oil dries up too quickly, while the heavier oils will not penetrate the surface quickly enough to prevent the skidding of automobiles or the picking up and carrying away of the oil onto the hard paved streets. In some instances, however, we eliminate any condition of this kind by covering the oiled surface with sand.

The grade of oil we have had the best results with is that of a gravity between .930 and 1.04 at 15° C. This oil is heated to a temperature between 225° to 275° F. Three applications of the oil at different intervals are applied during the season using approximately ½ gal. to the square yard for the season's work.

On streets that have not been heretofore oiled, ordinarily three applications of oil at different intervals will maintain the roadway in good condition during the season. On streets that have been oiled three years or longer, a substantial oil mat is usually formed, after which it is necessary to exercise considerable care in the amount of oil to be applied and the frequency of the application. This oiling is very light, approximately 1 gal. to 10 sq. yd. will serve the entire season.

The mat formed on oiled streets does not last indefinitely and is soon broken up by frost action during the winter or by heavy traffic. When this condition exists, it becomes necessary to rescarify the streets and the oiling process started all over again.

The first oiling of streets in St. Louis was in the year 1912, at which time we had two oil wagons of 500 gal. capacity each and used approximately 220,000 gal. of oil on 48 miles of streets.

In the year 1915 we purchased a 1,000 gal. oil truck, which, with one oil wagon, was put into service. Also during this year, we erected two 15,000 gal. storage tanks, and with the above equipment oiled 86 miles of streets, using approximately 760,000 gal. of oil.

The following year an additional 1,000 gal. oil truck was purchased, and we built two additional 15,000 gal. storage tanks, giving us a storage capacity of 60,000 gal. This year we discontinued the use of the oil wagon and with the two truck oilers oiled 130 miles of streets, using approximately 885,000 gal. of oil.

Since discontinuing the sprinkling of streets with water in 1927, we have oiled approximately 202 miles of streets annually using two of the three oil trucks continuously during the oiling season and only occasionally using the third truck.

At the present time, we are oiling over 200 miles of streets, approximately 2,125,000 sq. yd. of surface. During the fiscal year ending April 1, 1929, we oiled 202 miles or approximately 2,125,000 sq. yd. at a total cost of $42,448.58. This is approximately $210.14 per mile, or 2 ct. per square yard.

The price of oil during this fiscal year was 4.4 ct. per gallon. The labor cost of handling the oil received on our tracks in tank cars, transferred into storage tanks, and the heating and the distributing of the oil on the street is approximately 1¾ ct. per gallon.

Whenever we have occasion to do any sanding of the oiled surface, which is very seldom, we find that the cost varies for labor and material from ¼ ct. to ½ ct. per square yard in place.

Blotter Treatment of Gravel Roads in Minnesota

Methods and Costs of Bituminous Treatments on Gravel Surfaces and on Heavy Clay and Gumbo Subgrades

By F. C. LANG

Engineer of Tests and Inspection, Minnesota Highway Department, and Associate Professor of Highway Engineering, University of Minnesota, St. Paul, Minn.

THE Minnesota bituminous surface treatments were originally started for the purpose of improving two unsatisfactory but entirely different road conditions. First, on sandy soils where the road bed and surface gravel were both deficient in binder, resulting in a loose, uncompacted road surface, particularly bad in dry weather; and second, on heavy clay and gumbo roads where gravel surfacing had to be hauled long distances, making it very expensive, and when placed was effective only

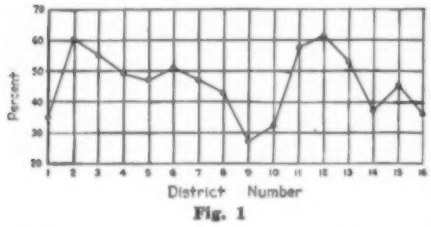


Fig. 1

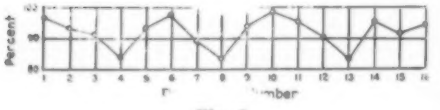


Fig. 2

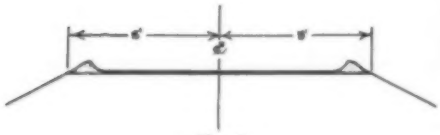


Fig. 3

Fig. 4

Fig. 5—First Operation: Grading Loose Gravel to Center of Road, Thus Forming a Smooth, Hard Surface for Penetrating with Bituminous Material

Fig. 7—Third Operation: After About 24 Hours the First Coat of Bituminous Material Has Completely Penetrated and Set Up. It Is Then Sprayed Again with ¼ to ⅓ Gal. of Bituminous Materal Per Square Yard and at Once Covered by Grading the Loose Gravel, Previously Removed, Back Into the Fresh Bituminous Material

a short time due to the fact that the granular material gradually sank into the heavy soil. Such roads were worst during wet weather. The treatments have given such general satisfaction that other types of roads have been treated until at present Minnesota has 784 miles of such roads on a Primary Trunk Highway system of 6,946 miles. There are also 1,149 miles of paving, and about 4,600 miles of untreated gravel roads in this system. There is a considerable mileage of bituminous treatments on the secondary system.

During the past six years many variations of the method of treatment for different kinds of road surfaces have been used. In this paper, however, I shall describe only the two distinct types mentioned. I believe that they most closely correspond to the title "blotter treatment." The elimination of dust, the conservation of material, and the better all year riding surface are, of course, in addition to the reduced cost of the roadway and vehicle operation—the reasons for bituminous treatments. The fact that mileage treated has so increased in Minnesota is evidence that bituminous surface treatments have been the most satisfactory improvement for certain types of roads. I shall confine myself to the description of methods used rather than giving reasons for bituminous surface treatments.

Gravel Used in Road Construction.—Before going into details regarding the bituminous treatments, I think it advisable to describe the kind of gravel and our method of constructing gravel roads. Minnesota has for years constructed gravel roads by the so-called feather edge method, using as a rule available local gravel which is usually of glacial origin. This gravel is used as it comes from the pit except that the part retained on a 1-in. circular opening is either crushed to such a size that it will pass this size opening, or if it is a small amount it is left in the pit. Occasionally excess fines are removed by a double screen operation.

Figure 1 shows a typical analysis of the gravel used in various sections of the state. You will note that from 28 to 60 per cent of the material is retained on a 10-mesh sieve, or in some instances gravels are used in which nearly three-fourths of the gravel put on the surface will pass a 10-mesh sieve. Figure 2 shows the percentage of that portion passing a No. 10 sieve which is retained on a 60-mesh sieve. You will note that very little passes a No. 60 sieve. This is quite a different gravel than some of you are accustomed to using.

Method of Construction.—In construction by the feather edge method, the subgrade is smooth and flat between shoulder lines which are usually about 30 to 32 ft. apart. Approximately 1,600 cu. yd. of gravel is dumped on the road and then windrowed onto the shoulders with blades, except that about 1 in. is left on the roadway. As the center compacts the blade brings in more gravel from the windrow along the shoulders until the road cross section is about like this (Fig. 3). Continuous maintenance is of course necessary. When roads are constructed in this manner on sandy subgrades with local gravel which is deficient in binder, we have the loose surface in dry weather which I previously mentioned.

Method of Treatment.—The method

Fig. 6—Second Operation: Spraying First Coat of Bituminous Material; ¼ to ⅓ Gal. Per Square Yard

Fig. 8—Fourth Operation

of treatment for such a surface is as follows:

The first operation (Fig. 5) consists of grading all of the loose material to the center of the road, thus exposing a smooth hard surface. In only a few instances have we resorted to sweeping, for usually the surface is such that sweeping would not be possible. The ideal road surface at the time of the first application should be smooth, well compacted, dry, and free from dust.

The second operation (Fig. 6) is the spraying of the prepared surface with about 0.3 to 0.5 gal. of heated bituminous material.

Third operation (Fig. 7)—After about 24 hours, or when the first application has completely penetrated and set up, the surface is again sprayed with ¼ to ⅓ gal. of bituminous material, and at once covered by blading the loose material previously removed onto the fresh bitumen. This would be considered the "blotter coat." In case the bladed material contains an excess of fines of a non-granular nature, it is wasted over the shoulder, and suitable material for covering is windrowed on the opposite shoulder, bringing the total amount of covering material up to about 350 cu. yd. per mile. The best covering material is gravel or, where available, stone chips, all passing a ⅜ or ½ in. screen and having from 15 to 30 per cent passing a No. 10 sieve. Where we have aggregate plants near, such a material is used. Usually, however, selected local deposits are used and the amount passing the No. 10 sieve may be as high as 60 per cent.

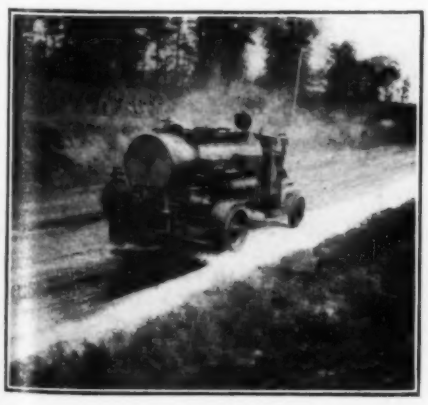


Fig. 9—Fifth Operation

Fourth operation (Fig. 8)—The opposite side of the roadway is then cleared with a grader, throwing the loose gravel into a windrow over the edge of the treated section and leaving the opposite side free for treating.

Fifth operation (Fig. 9)—The remaining side is treated with penetration coat and allowed to set up the same as the first side treated.

Sixth operation (Fig. 10)—This side is then treated with a second coat of bituminous material and loose graded material bladed in from side for cover the same as before.

Seventh operation (Fig. 11)—The roadway is dragged a number of times to smooth it and work all the gravel possible into the bituminous material. This dragging operation is continued for a period of three to five days, or until the surface has set up to such an extent that dragging does not do any good, or the surface at that time is in a hard condition. At this time any small breaks or holes should immediately be patched with pre-mixed material, using the same grade of bitumen and the same aggregate as is used for the blotter coat. If large holes develop, a coarser grade of road metal may be used to insure a more stable patch.

Fig. 10—Sixth Operation

At completion, the crown for a 30-ft. top would be from 6 to 9 in. This method is really a combination of the penetration and surface mixing methods. Its success depends largely on penetration into compacted surface. The thickness of the bituminous mat after the first treatment is about ¾ in. Subsequent treatments, scarifying, etc., increase the thickness of the mat, and result in it becoming 3 or 4 in. in thickness. In this class of treatment in the past, tar has usually been used, but we have recently made some use of cut back asphalt and it appears to be very promising.

Handling Traffic During Treatment.—Traffic is usually carried continuously on the road, although where it is easy to detour, this should be done. The traffic is carried on the untreated side until after the blotter coat is applied, after which it may immediately be carried on the treated section. Where there is considerable sand in the blotter coat, we have little trouble with the material picking up and annoying the motorist. If the blotter coat is entirely loose pebbles there may be considerable trouble. Although it may make a better road in the end, it will be very troublesome during this period under traffic. On one treatment on the north shore of Lake Superior in 1929 we used a cover coat of lake shore gravel pebbles between ¼ and 1 in. size. Cars passing through were quite badly spattered. Such a covering did not act as a blotter. In most of our road construction, the sand content in the blotter coat has been rather high.

Fig. 11—Seventh Operation

We place warning signs at the ends of the sections being treated informing the motorist what to do. We also occasionally place patrolmen at the ends to stop the motorist and tell him how to proceed. Occasionally the flagmen only permit traffic in one direction on the portion of road being treated so as to avoid turnouts. In a few places where traffic was especially troublesome, we have had highway patrol officers. The traveling public should be protected. Any unwarned motorist who gets his car spattered with bitumen has a just grievance. The proper method of protecting the motorist depends on method

Fig. 12—Condition After One Year's Treatment with Bituminous Material North of Ada, Minn.

of treatment, intensity of traffic and local conditions.

Costs.—On this type of road construction the daily traffic varies between 700 and 1,500 vehicles per day. Initial cost for a 24-ft. surface ranges between $1,600 and $1,800 per mile. One patrolman with auxiliary equipment and help can successfully handle about 20 miles of this kind of road, taking care of patching, cutting of grass, repairing washouts, etc. On a typical section of such bituminous treatment north of Brainerd, Minn., on Trunk Highway No. 19, 17.6 miles were first treated by the method just described in 1926. The cost of the first treatment was $1,669 per mile. The entire cost of maintenance of the surface for 1927 was $995. This included in addition to the usual patching a retreatment of about ¼ gal. per square yard of bituminous material and 125 cu. yd. per mile of cover. The entire cost for 1928 was $416, which included blading, smoothing, patching, etc., but no retreatment. In 1929 the road was retreated in a manner similar to the 1927 treatment at a total cost of $1,044. This particular road carries more traffic than is ordinarily the case on our bituminous treatments. The traffic count Aug. 5 to 11, 1929, was 2,109 vehicles per day. The maintenance on this road is such that at practically all times it provides as good and satisfactory a riding surface as would a pavement.

Treatment of Heavy Clay and Gumbo Subgrades.—The initial treatment of road oil on heavy clay and gumbo subgrades was in 1925 in the northwestern part of the state. This area is very flat, being the bed of glacial Lake Agassiz. Gravel had to be shipped long distances and the road became slippery and greasy a very short time after a heavy coat of gravel was placed on it. The feather edge method of construction previously described was used. It was found that the more fines there was in the gravel the longer time it would take for it to sink into the heavy soil underneath. A blanket coat of such material under the gravel was the method of construction often used in that area up to the time that oil was first used. It was not, however, in general a satisfactory method of construction. Oil has been much more satisfactory and less costly.

On new construction the oil is placed directly on the subgrade, which is about 30 to 32 ft. wide between shoulders, and should be smooth and have little crown at the time the oil is applied. An idea of the nature of the subgrade in this area may be obtained from the following analysis:

	Per Cent
Passing No. 10 sieve	99.5
Total sand	8.6
Total silt	21.8
Total clay	69.6

A typical analysis of the oil most generally used is as follows:

Specific gravity	1.044
Flash	164° C.
Specific viscosity at 60° C.	12.9
100 Penetration residue	65.2
Ductility of residue	100+
Loss at 163° C.	2.8
Total bitumen (soluble in CS_2)	99.91
Total bitumen insoluble in 86° Naptha	16.23

Considerable care is taken to see that the subgrade at the time of treatment is well compacted, smooth, free from dust, and dry. Weather conditions play a great part in the satisfactory application of oil on this class of work. Warm weather aids the penetration of the oil into the subgrade. Rainy weather tends to slow up the

Fig. 13—Condition of Adjacent Untreated Section

work because it is difficult to get the surface dried out sufficiently to obtain the necessary penetration into the soil.

About 400 cu. yd. of cover material per mile is used. The cover material as previously described is preferably pea size with a small percentage of sand, but usually selected local deposits are used. The gravel takes the wear. Too much emphasis cannot be placed on having the surface of the road well above the water table. The thickness of the oiled surface is about ¾ in. This is not sufficient to assure the carrying of extremely heavy traffic, or the carrying of ordinary traffic if the soil beneath this thin crust is plastic. We employ heavy grading in these sections, running 16,000 to 22,000 yd. per mile for a 30 to 32-ft. road. This brings the surface of the road from 4 to 5 ft. above the bottom of the ditch line and the ditches are usually quite wide. Figure 12, taken on road north of Ada, Minn., is typical of roads in this area. This picture was taken after heavy rains. Notice the water in the ditches. Contrast that with Fig. 13, which was taken on an adjacent untreated section. The difference is most pronounced when the frost is coming out in the spring. I do not believe our treatment of this type of road would be effective if it were not for the high grade line which adds to the stability of the road bed.

Also there is a considerable difference in the supporting power of the different clay soils. Some so-called clay soils contain a high silt content and their supporting power when wet may be compared with quicksand, while other clays like the familiar blue clay will always have a good load carrying capacity. The soil in the subgrades we have treated is the latter type. Such a soil absorbs water very slowly, but is extremely sticky and disagreeable when once wet. This thin bituminous crust acts as a roof over the road and sheds the surface water. It also forms a crust or, perhaps you might say, a diaphragm over the clay which prevents the gravel from sinking into the soil underneath. I do not believe that such a method of treatment would be at all satisfactory, unless drainage was taken care of and the subgrade was of a stable composition.

Costs.—The initial cost of this type of treatment is about $1,400 to $1,600 per mile. The bituminous material used does not form a hard mat and can be cut with blades, especially during the hot weather. As a result there is considerable blading in the maintenance. In patching we use a mixture of the road oil and cover gravel. On a typical section south of Ada, Minn., on Trunk Highway No. 6, 25 miles were first treated in 1926 by the method just described. The cost of the treatment was $1,448 per mile. In 1927 the road was retreated, using more bituminous material and more cover at a cost of $1,262 per mile. The maintenance for 1928, with no retreatment, was $615 per mile. Maintenance for 1929, with no retreatment, will probably be about the same as for 1928. The traffic during period of Aug. 5 to 11, 1929, was 703 vehicles per day. This road is very much better during wet periods than are adjacent untreated gravel roads.

In conclusion I wish to urge the necessity of further research. A method of treatment suitable in one place may be entirely unsatisfactory in another. Then, too, a large amount of money may be spent in bringing in material to build the surface in some standard manner, whereas, if we only knew how, it is entirely possible that a suitable surface might be constructed from local materials at a much less cost. Thus a much greater mileage of suitable roads would be obtained at the same cost. Last winter we experimented in our laboratory on penetration of different bituminous materials into clay soils. We made up balls, about the size of golf balls, and found that by soaking them in oil a certain length of time we got a maximum penetration of about ⅛ in., whereas by adding a small amount of hydrated lime to the soil the bituminous material completely penetrated to the center. I mention this not only to indicate that there may be possible methods of improving the soil before oiling, but also to point out that the soil properties may not always be the same on different roads, even though they have the same general appearance. There is a considerable difference also in the behavior of different road oils on these heavy soils.

Acknowledgment.—The above is a paper presented at the 8th annual Asphalt Paving Conference.

Pavement Opening and Restoration

A Brief Outline of Practice in Various Cities That Have Proved Successful and Popular Methods Now in Use

IN the opening of new territory where paving is proposed, subsurface structures should be installed prior to the laying of the pavement, but it would not be economical or indeed, possible to make all connections for sewer, water and gas for all lots fronting on a street before the pavement is laid. This is done in some instances and to some extent by laying house connections from the sewer to a point beyond the curb line, but it involves a large expenditure of capital, about half of which may never be of use. The water department of Los Angeles has adopted the policy of placing house connection laterals on division lines between lots, thus serving two lots from one lateral connection. This is satisfactory unless there is a radical change in the use of the property. These services are included as part of the paving proceeding and assessed against the vacant property. When service becomes active, no charge is made for setting meter, inasmuch as the property has been assessed for the installation previously.

With the installation of sewer house connections to a point beyond the curb line, if sewerage has to be pumped or treated the practice will probably add considerably to the flow by the infiltration of ground water. At most, it may be said that the main lines of water, gas, sewers and electric conduits should be laid before paving and that a proportion of the frontage on the street, estimated at 50 per cent, should be built up. If this practice has been followed, there will then be only the openings for new buildings and those for repair to connections from old buildings. An attempt to discourage openings in new pavements and encourage the installation of subsurface work ahead of the pavement is made by an announcement by the municipality that no openings will be permitted for a given period after paving.

However, as a matter of fact, the announcement of a period of "no openings" is almost entirely bluff and cannot prevent more than a small proportion of openings. The cooperation of utility companies can be secured and this will help conditions materially. Well managed companies can and have anticipated a large percentage of changes in the use of property, thus avoiding the necessity of laying new mains.

Permits and Inspection.—In a survey covering a number of cities, it is found that permits are required in every instance before openings are made.

In emergency cases such as gas leaks, utility companies are usually allowed to open without permits. In some instances utilities have blanket permits covering this and notification of the authorities by telephone is sufficient. As a rule, however, in emergency cases utilities must obtain permits later and in many instances the permit must be secured within a definite period after the opening. In a few instances the permit is issued when the resurfacing is ordered.

In the majority of cases there is no fee charged for the opening. In others there is a sufficient amount charged to cover inspection and placing of pavement. One large city makes a high charge to prevent openings in new pavements, this amounting to $75 for cutting a new pavement and $50 for a second year pavement without refunds.

In the event of the opening of continuous trenches, the usual practice is to issue a permit to cover the entire length of the excavation.

Permits are usually issued to corporations, contractors and plumbers who are bonded.

The replacing of backfill is generally done by the permittee but the city replaces the pavement. Where city does the work, deposit amounting to estimated cost is required.

In the greater percentage of the cities investigated, no provision is made to cover future backfill settlement and necessity for future restoration. In few instances bond is required—where utilities are operating under a definite franchise, the bond being retained indefinitely.

Many cities issue blanket permits to cover extensive pipe laying contracts, while others issue permits for each street. Uniformity is lacking. The blanket permit, however, if used in conjunction with good supervision seems to be satisfactory.

Backfill settlement is not considered as an obstacle to the prompt replacement of pavements in the majority of cities, most municipalities taking the position that quick replacement prevents criticism and avoids danger of subsidence in the adjoining area.

There is little uniformity on the life of the permit, the time limit without renewal or issuance of new permit varying from 10 days to 1 year.

Some cities have provisions controlling the hours of labor on openings and many of them require night and day shifts in business or traffic congested areas.

Municipalities as a rule provide inspection for backfilling and pavement replacement. This may be full time or occasional, but nearly always on completion.

The majority of cities include the cost of inspection in the pavement charges.

It is evident from the foregoing summarization that there is a considerable diversification in the practice followed in different cities.

In brief it may be stated that when openings are neecssary the work should never be allowed to start until the issue of a permit has been granted by the city authorities, preferably by the department having the pavement in its care. The issue of a permit should automatically notify the street maintenance department to enable it to be ready to inspect the work. It may not be practicable to secure inspection by the city for the entire work of refilling the trench but even occasional visits by an inspector will have a good effect. The restoration of the pavement should, without question, be done either by the city or town itself, or under its close inspection. With all the care which may be given to the restoration, the cuts will always be weak spots and be the cause of a large portion of the repairs of the future. No pavement can be restored to its original condition by a patch and the most an engineer can do is to see that the restoration is made as carefully as possible over a trench which has been refilled according to the best methods of backfilling.

Methods of Restoration

Backfilling. — To secure maximum compaction the backfill should be thoroughly compacted either by tamping or flushing during refilling. Leaving the fill higher than the surrounding paving and expecting the traffic and the elements to consolidate it, is simply relieving the permittee, for whose benefit the opening was made, of an obligation at the expense of the general public. Moreover, traffic does not consolidate the fill to any great depth, probably not more than to the subgrade of the pavement. The fill would gradually settle under the pavement due to vibration and impact even though the cut remains unpaved for years. Instances of this have been noted where sewer trench has been filled but left unpaved for years and in a short time after the paving of the street the line of the trench could be easily traced for many blocks.

It is useless, therefore, to defer restoration for any great length of time and is certainly unfair to the travelling public.

Another reason for prompt restoration is the fact that traffic enlarges the area to be restored very rapidly and undermines the foundations. This increases the cost which cannot reason-

ably be charged to the permittee, but must be borne by the town. The additional expense of a delayed restoration may easily be double the first cost.

Various methods may be used to encourage careful and proper backfilling of the trenches, but one of the best is to retain a deposit sufficient to cover the cost of a second restoration of the pavement, if the first patch fails within a given period of possibly 6 to 12 months.

Instructions to plumbers or other parties making openings can be printed on the permit forms and the methods to be used made a part of the permit conditions.

The policy of city or town authorities requiring prompt restoration of cuts is becoming increasingly popular. The time limit, of course, varies. In cities which have their own paying forces, it may be as short as 5 days nominally, or from 10 to 14 days. This period of restoration is as prompt as possible allowing for a notice of the refilling to reach a central office, issue of orders to the workmen and the latter's visit to the cut; also allowing for necessary travelling between cuts and for two operations—by concrete forces and asphalt forces.

In towns which do not operate their own paving plants, cuts, as well as general maintenance patching, must wait until there is sufficient to warrant the issue of an order or contract to a paving company. This is especially the case with asphalt pavement. In the case of block pavements, the town or city can usually keep men employed who are capable of laying a concrete foundation, a block wearing surface or a macadam pavement.

Concrete.—The first step in restoration has already been mentioned, namely, the backfilling. This is of greatest importance as the solidity or load capacity of the sub-grade of the pavement to be replaced is the most essential factor in the life of the pavement.

To secure proper support for the new portion, the old pavement should be removed for a distance of 4 to 6 in. beyond each side of the actual opening of the trench to obtain a bearing on solid ground. If the foundation is concrete this will also allow for breaking off concrete to obtain a clean face, as well as an inclined surface to secure a wedge or arch effect for the new concrete slab. There is little use to expect any cohesion of the new concrete to the old but the beveling of the old concrete will give support to the new by acting as an abutment. Concrete should be given time to set before applying the wearing course, but it will be found that covering the new concrete in two or three hours with earth from the excavation will give sufficient protection until the surfacing forces can start the laying of the top. In two or three days at the earliest the concrete will have acquired sufficient strength to permit the laying of any kind of surfacing. Careful inspection of cuts restored according to such a schedule has failed to show any appreciable percentage of damage by traffic and but little relaying work has been necessary.

Bituminous Surfaces. — Restoration using bituminous concrete, "black base" as it is called, has the advantage of requiring only one operation and one visit of repair forces. These forces place both the base and the sheet asphalt top.

Whether the wearing surface is sheet asphalt or bituminous concrete, the base is usually of a coarser mix, that is, having larger sized aggregate. In any case, the base should be thoroughly tamped, if it cannot be rolled and allowed to cool to some extent before the top is applied. Otherwise, the total mass will retain its heat and make proper rolling and compaction difficult.

The wearing surface should be cut back beyond the edges of the original cut, leaving a perfetcly clean edge which should then be painted with A. C. This will give actual cohesion of the new material to the old, also preventing water from entering the joints and injuring the pavement. It is to be remembered that water remaining for a long period on or under an asphalt pavement will seriously damage it.

Block Pavements.—Restorations using block pavements, whether granite, wood, or asphalt should be laid with care to have the new surface flush with the adjoining surface and particular attention should be given to the matching of adjoining courses. Two courses running into one or three into two should never be allowed and the rules that the restoration be equal in strength and quality to the adjoining pavement should be insisted upon.

Conclusion.—Cuts and trenches must be expected in varying numbers depending upon the progress of the community and these openings will always cause damage to the pavement, but with care in backfilling and the replacing of wearing surface, the damage can be greatly reduced. This can only be secured, however, by close and efficient inspection and education of the forces making the cuts and restoring the pavement.

Prompt restoration will earn for the city administration the good will and commendation of the travelling public to a greater extent than can any criticism of a slight settlement later can do them harm. Bumping over or dropping into a mud-filled cut day after day while driving or riding in an automobile does not improve the opinion of the travellers as to the capacity and energy of the city government.

The foregoing is taken from a report of a sub-committee of the City Officials Division of the American Road Builders' Association presented last month at the annual convention of the assocation.

Prequalification Required in Tennessee Now

The Department of Highways and Public Works of Tennessee now requires that prospective bidders demonstrate their qualifications before being permitted to bid. The plan went into effect on Jan. 1. The following is the official notice of the department:

"To Contractors Bidding on Highway Work in Tennesseee

"The classification of contractors or prequalification of contractors has been in effect for some time in several states, with good results both to the responsible contractors and to the states in which this method has been in use.

"The custom in Tennessee prior to this date has been to accept a bid from anyone desiring to submit same. He was required to submit a questionnaire to be filed with the department before the time set for opening bids.

"After opening bids it had to be determined who was the lowest responsible bidder.

"This letter is to advise that effective Jan. 1, 1930, the department of highways and public works will institute a prequalification plan whereby it will be necessary for the contractor to have on file with the department a new form of questionnaire executed after Jan. 1, 1930, before he can obtain a proposal for use in bidding.

"In this connection if previous work has not been satisfactorily handled in every respect and if claims have been filed with the department either for labor or material, the contractor is to be advised that his standing will be considerably lowered.

"No contractor who has never had a general contract with the department will be awarded a contract in excess of 10 miles in length and such contractor who has not successfully completed 50 per cent of his first contract will be considered, this percentage to be computed from the latest current estimate on file in this department."

Removal of Unnecessary Litter on Streets Costly.—In an address at the 1929 convention of the International Association of Street Sanitation Officials, W. S. McGrane, manager Anti-Litter Bureau of the Merchants Association of New York stated that fully 90 per cent of the debris removed from the streets of New York City and amounting to perhaps 800,000 cu. yd., consists of litter openly or surreptitiously, but nevertheless deliberately placed in the streets. The cost of sweeping up such litter, hauling to dumps or to incinerators and destroying same may be conservatively estimated at $8 per yard, amounting to $6,400,000 per annum. That is nearly one-quarter of the budget of the street-cleaning department.

Surface Treated Sand-Clay Roads in Georgia and Florida

Methods of Constructing Sand-Clay Base for Surface Treating and the Materials and Methods Used in the Treatment

By B. P. McWHORTER

Asphalt Engineer, State Highway Board of Georgia

IN the northwestern part of the state of Florida and the section of Georgia south of the fall line practically all the roads were at one time surfaced with sand clay as a wearing surface. As the roads were relocated and graded to the present day standards of construction a sand clay surface of selected material was invariably placed on top as a wearing surface until the subgrade became thoroughly settled. Not only did this surfacing answer as a temporary surface but formed a stable subgrade upon which to lay the more permanent type of surfacing to follow.

It soon became apparent that funds were not available to surface all the graded and improved roads with the so-called permanent surfaces such as concrete or standard asphalt pavements. In order to provide relief for the people using these hard roads and to protect the investment in the bases and at the same time provide a hard surface at a nominal cost experiments were conducted toward surface treating this type of road.

The sand clays of Northern Florida cannot compare in their composition with the high grade sand clay deposits of Georgia. In Georgia we have excellent deposits of chert in the northwestern part of the state, clay gravel and top soils in the central portion and sand clays and iron oxide silica in the south central and southwestern portions.

Great care should be exercised in the construction of sand clay bases in order to secure bases characterized by high stability and which are not affected to a great extent by water. Under this category comes the chert deposits, gravel deposits, top soils and iron oxide silica soils of Georgia.

A sand clay soil of the mechanical composition having high stability must have from 10 to 18 per cent clay, 5 to 15 per cent silt, total sand 65 to 80 per cent. When coarse material above a No. 10 sieve is added it increases the stability and gradually increases until the full type of gravel slab is reached.

In South Central and Southwest Georgia there are large and numerous deposits of iron oxide silica and from past observations we believe this material makes the best base material for surface treating in the state outside of the lime rock bases. This material is characterized by high stability and makes an excellent wearing surface when not surface treated. It is affected least by water of any of the clay bonded type bases with the exception of the chert or top soils. The characteristics of the raw materials and quality of binder makes it better than any of the bank run gravel deposits we have. The analysis of Table I shows that this soil contains 15.9 clay 49.7 per cent coarser than 60 mesh 34 per cent above 10 mesh and 28 per cent above a ¼ mesh.

It is estimated that Georgia has sufficient deposits along the state highways in the southwest section of the state to construct approximately 1,000 miles of this type of base 8 to 10 in. thick. This does not take into consideration county roads which will easily run to 2,000 miles additional.

The State Highway Department of Georgia constructed quite a large mileage of chert, gravel, top soil and iron oxide silica bases at a cost varying from $3,000 to $10,000 per mile and allowed them to go unsurfaced for a number of years. Statistics proved that these roads depreciated from $600 to $1,500 per mile per year depending on the amount of traffic. When funds became available to surface these roads it was found that in most cases the base had to be renewed at generally 50 per cent of the original cost. The present ruling of the Board is to surface treat all remaining bases at the earliest possible time and to construct only this type of base with a view of surface treating it within six months in order to preserve the initial investment in the base.

After we have completed surface treating the present gravel bases and top soil bases most of the surface treatments will be confined to clay gravel, top soil, chert and iron oxide silica soils, and then only within those sections where the materials can be obtained locally. We have surface treated all types and it is my opinion that the pebble soils or iron oxide silica bases give much better results than any other type of base we have outside of lime rock.

A base composed of 8 in. of iron oxide silica can be constructed for from $3,000 to $4,000 per mile and a surface treated top of the type we use for from $2,000 to $2,200 per mile, making a total investment of from $5,000 to $6,200 per mile. In my opinion there is no better investment a state can make than this type of construction on their secondary roads.

Methods of Construction.—The most important step in the construction of surface treated roads is drainage. The composition of the materials is of such nature that water or moisture will act on the base and cause failure in the surface treatment.

In case the base absorbs water by capillary attraction or otherwise in sufficient quantities the traffic will form an emulsion and gradually destroy the bonding qualities of the bituminous materials.

Adequate side drainage should be provided and through cut French drains constructed if necessary, so as to insure a dry base at all times.

In the construction of a sand clay base for surface treating great care must be exercised as previously stated in selecting the soils that have high stability. The quality of clay forming the binder is very important. Clays differ greatly in their texture and care should be taken not to use clays that are easily softened by water, such as gumbos or clays that come in this category.

The general method of constructing a sand clay base is to lay form boards 12 in. in depth and deposit the natural sand clay mixture, if of an artificial mixture, in their correct proportions

Table I

Sample Number	1	2	3	4	5	6	
Sand ret. 20 mesh	2.7	6.8	4.1	7.2	3.8	7.7	
Passing 20 ret. 60	50.5	48.4	45.5	45.4	37.2	40.6	
Passing 60 ret. 200	26.8	20.0	28.1	25.0	32.8	26.4	
Total sand	80.0	75.2	77.7	77.6	73.8	74.7	
Total silt	7.2	5.8	8.2	7.0	9.4	7.9	
Total clay	12.8	19.0	14.1	15.4	17.4	15.9	av. 15.9
Sand coarser than 60 mesh	53.2	55.2	49.6	52.6	41.0	48.3	av. 49.7
Material above 10 mesh	36	29	20	33	50	35	av. 34%
Percentage Analysis of Materials Ret. No. 10 Sieve:							
Ret. 1½ in. screen							
Passing 1½ in. ret. 1 in	13				13		
Passing 1 in. ret. ¾ in	13	18	15	3	10	11	
Passing ¾ in. ret. ½ in	23	23	15	15	25	19	
Passing ½ in. ret. ¼ in	39	37	52	39	38	39	
Passing ¼ in. screen	12	22	18	12	14	31	
Above ¼ in	29	23	16	29	43	24	av. 28

Florida Bituminous Surface Treatment of Sand-Clay. Traffic Passing over Road on Crushed Rock Cover Shortly After Bituminous Seal Coat is Distributed

determined by laboratory tests, to the top of the forms. Twelve inches of material will usually make 8 to 8½ in. of compacted material, depending on the shrinkage of the material used. The sand clay should be scarified and harrowed thoroughly to produce a uniform mixture and then machined constantly with a 12-ft. blade until the surface becomes compacted and smooth.

In Florida, due to the quality of clay available they have found it advisable to add about 2 cu. yd. of pea gravel over the surface for each 100 ft. of base and allow the material to work into the surface under traffic, and constant machining with a one man power grader. The pea gravel is added after the sand clay has practically taken its initial set. This method forms a crust or veneer surface that greatly increases the stability of the base. In Georgia we have such excellent sand clays coming under the high stability group that we seldom have to add metal to bring up the supporting value.

Under the iron oxide silica group or red pebble soils of Georgia we have a natural material that excels all other materials coming under this group. Deposits of this material are found on top of ridges or hills and run to a depth generally of 3 ft. from the top of the ground. The material is laid between forms generally 12 in. loose which compacts to about 8½ in. After thoroughly mixing the material to get a uniform product the surface is machined generally with a 12-ft. blade until the true cross section and crown is obtained. The characteristics of this material is that it cements together very quickly, usually a couple of good rains are sufficient for a thorough bond. This is not true of sand clay or gravel bases which generally take a month or so to form their initial set.

Prime Coat.—During the early experiments in Florida asphalt primes first used did not prove very successful. Of these, material meeting the O. C. 2 specifications was most unsatisfactory.

I quote Mr. R. L. Bannerman, division engineer of Florida, as follows regarding the use of asphalt primes in this early work:

"The principal trouble with asphalt for prime is that it requires too long for the prime to cure, which delays the application of the seal. Under heavy travel the prime tends to pick up before the same has cured sufficiently for sealing. Another trouble is the light oils in the asphalt prime tend to cut back the seal coat, which has caused us a great deal of trouble on the sections of road on which these materials were used."

Florida's experience, using asphaltic road oils as primes, covered a period about four years ago. They failed to attach themselves to the base, set up quickly and provide the hard mat needed to cause the seal coat to adhere to the same, and for this reason tar prime has since been used.

Since the introduction of cut back asphalts satisfactory primes have been developed which have proven equal or superior to tars in many sections they have been used.

The next move was to find out the amount and viscosity of the bitumen to use. It was found that this depended on the density of the base and character of clay used as a binder. The lime rock bases absorb from two-tenths to twenty-five hundredths per square yard of an 8-13 viscosity bitumen. The clay gravel bases will take three-tenths to thirty-five hundredths of 13-18 or 18-25 viscosity depending on the porosity of the material. The iron oxide silica soils take four-tenths of an 18-25 viscosity bitumen and the penetration in this material will average ¾ in. The engineer, therefore, must be familiar with the soils he is treating in order to determine the amount per square yard and the viscosity of bitumen to use; this can be obtained only by experience.

The prime should be allowed to penetrate from 24 to 48 hours, depending on the temperature and longer if good detours are available before turning traffic on the surface. Only a small amount of cover or blotter material should be added, as it will absorb the bitumen, forming a mat with no adherence to the base. Moisture will then form between the base and cover, causing a cleavage and cracking of the surface. Traffic should be allowed to use the primed base for at least two weeks to thirty days (depending on climatic conditions) in order to iron out any weak or soft spots before applying the seal coat. In case weak spots develop they should be cut out, reprimed and brought to a true plane with surface by means of an asphaltic cold patch or other suitable material. During a two weeks period between April and October in Georgia the prime will generally cure if the weather is favorable and form an impervious tough surface.

Application of the Seal Coat.—The prime having thoroughly cured the base should be swept clean of any foreign matter before applying the seal.

The seal consisting of an asphalt 180-200 penetration is then applied hot at the rate of 4 tenths to 5 tenths gallon per square yard. On lime rock bases 4 tenths gallon per square yard have been used in Georgia while Florida has increased the application to 5 tenths gallon per square yard. On clay treated bases 5 tenths gallon per square yard has been adopted by both states. I believe the quality of work obtained with the larger amount of asphalt will

Distributing Seal Coat on Bituminous Treatment on Sand-Clay Surface West of Tallahassee, Fla.

justify the increase. The temperature at which the asphalt is applied usually ranges from 300°F. to 325°F.

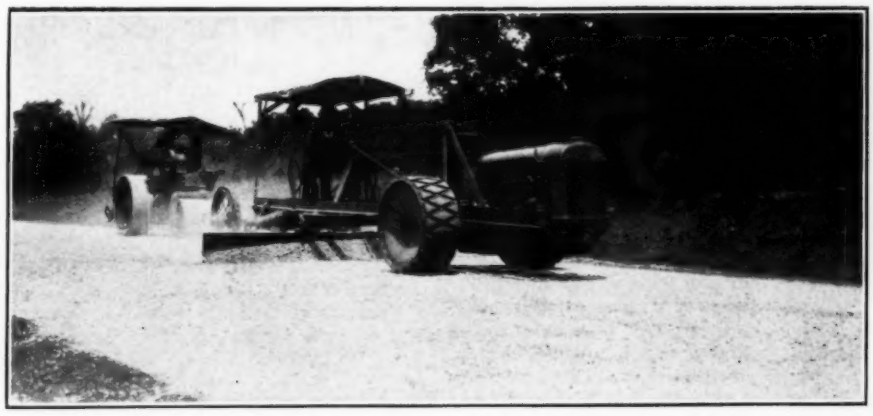
The cover material consisting of stone or slag should be spread immediately after the application while the asphalt is still hot. The cover material should be thoroughly rolled immediately with a roller weighing not less than seven tons. A 10-ton 3-wheel roller has been used with excellent results but the usual practice is to use a 7 or 8-ton tandem. The drift to the edges should be kept swept back uniformly over the surface until the asphalt has taken up the maximum amount of cover material. During the first surface treatments in Florida they used O.H.-1 for the seal coat. This material did not prove entirely satisfactory so they adopted what is known as O.H.-1 modified having the following specifications:

The asphalt shall not foam when heated to	248° F.
Specific gravity at 77° F. not less than	1.000
Flash point not less than	400° F.
Melting point (ring and ball) not less than	90° F.
Penetration at 77° F. 100 grams 5 sec.	180-230
Loss at 325° F. 5 hr. not over	1.50%
Penetration of residue not less than	150
Total bitumen soluble in CS_2 not less than	99.5%

This material has also been adopted by Georgia with excellent results.

Opinions differ as to the size and kind of cover material, but the following size has been universally adopted by both Georgia and Florida.

Slag gives better results than stone and a greater percentage of the cover material is composed of this type. It is more cubilar in form and assures an interlocking of the aggregate and a mechanical bond under the roller that we do not obtain with stone. It does not dust or fracture as easily under traffic as the Georgia granites and is free of flat or elongated particles so detrimental to bituminous surfaces. On account of its cubilar shape, porous and angular nature it imbeds itself in the bituminous binder and forms a greater adhesion to the base. The cubilar shape produces a nonskid surface and does not have the tendency to iron out under traffic as does stone.



Blading Crushed Slag Uniformly over Seal Coat in Florida Bituminous Treatment

An inspection of the surface treated roads in Georgia and Florida will convince any one that a slag cover material is the equal if not superior to any other type of cover.

On the early surface treatments a cover material ⅝ to 10 mesh was used this soon ironed out and became very slick and dangerous to traffic in wet weather. This size was soon abandoned for a ¾ in. to ¼ in. which gave excellent results when 0.4 gal. of asphalt was used.

Florida has roads with this size cover material that are seven years old and still giving excellent service.

Both Georgia and Florida have adopted a cover material 1 in. to ¼ in. in size which appears from many angles to be superior to the smaller sizes. It does not have such a tendency to iron smooth and become slippery in wet weather, forms a nonskid surface and at a later date will more successfully take a retreatment. The amount of cover material may vary slightly but usually ranges around 10 lb. for each 0.1 gal. of bituminous material, in other words we generally use 50 lb. for 0.5 gal. of asphalt which is our standard surface treatment.

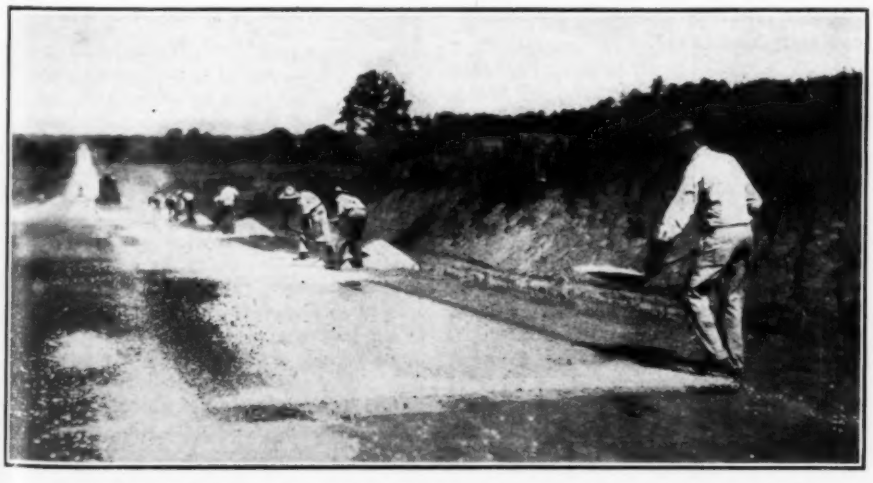
This year we tried in Georgia what may be termed a double treatment on a 2½-mile section next to Moultrie, Ga. After the first treatment had been subjected to traffic for three months a second application of 0.3 gal. per sq. yd. of cut back asphalt was used having the following specifications:

		Min.	Max.
1.	Specific Gravity at 60° F.	0.980	1.01
2.	Engler Specific Viscosity, first 50 cc. at 212° F.	25	50
3.	Asphalt Contents at 100 Pen.	85.0%	.....
4.	Ductility of Residue at 77° F.	100 Cms.	.....
5.	Evaporation loss 20 Grs. 5 hr. at 212° F.	10.0%	13.0%
6.	Penetration of Residue at 77° F.	.....	200
7.	Evaporation Loss 50 Grs. 5 hr. at 325° F.	12.0%	15.0%
8.	Penetration of Residue at 77° F.	.....	125
9.	Bitumen Soluble in CS_2	99.5%	.....
10.	Per cent of Total Bitumen Insoluble in 86° Naphtha	20.0%	.....

This treatment was covered with 25 lb. of ⅝ to 10 mesh slag. The surface was immediately rolled as well as swept with a 7-ton tandem roller, and the drift of cover material kept swept over the surface until the asphalt was cured and had taken up the maximum amount of cover material. This retreatment formed a tough, smooth, durable, and impervious surface. The type of cut back asphalt used did not have sufficient solvent to cut back the first application but a sufficient amount to form a perfect bond with the surface. The curing period for this grade of cut back asphalt is not over five days and leaves a surface that will not bleed or iron out thereby causing a slippery condition in wet weather. The merits of this double seal cannot be proven at this time but I am sure is worth the investment provided funds are available. It will increase the cost approximately ten cents per square yard.

Too much credit cannot be given J. L. Cresap, former state highway engineer of Florida, and R. L. Bannerman, division engineer, for developing and bringing the treatment of sand clay roads up to the standard that is found in Florida and Georgia today.

Quoting Mr. Cresap he says we have in Florida treatments on sand clay as



Spreading Crushed Stone Cover on Bituminous Surface Treatment of Sand-Clay Road

much as two years and nine months old still giving good service under traffic as high as 1500 cars per day, and believe with proper care in selecting materials and constructing the work properly that sand clay roads can be built and surface treated with assurance that they will carry traffic up to 2500 cars per day, with a maintenance cost equal to that of other types of pavements.

Mr. Bannerman who possibly has had more experience than any other person in this section in the maintenance of sand clay treated roads believes that if the road is properly constructed the maintenance will be nominal and that retreatments will be needed only every four to five years at an approximate retreatment cost of 10 ct. per square yard.

The low cost road or one that is dealt with here is capable of carrying medium heavy traffic at a minimum maintenance cost and can be termed one of stage construction. At any time it can be changed into a high type pavement, by constructing a black top such as Amiesite, Macasphalt, or any of the other cold mix asphaltic types without stopping traffic. It is also an excellent base for laying the hot mix types such as binder and sheet, asphaltic concrete or any of the hot mix types, with very little or no base preparation except the construction of a curb for holding the materials.

The future for this type of road is in its infancy and in Georgia the mileage of bases suitable for this type of construction will amount in a few years to several million dollars annually.

Not only eliminating the dust hazard but the investment in surface treatment will save hundreds of thousands of dollars annually by retaining the initial investments in the chert, clay gravel, red pebble, top soil and sand clay bases.

Acknowledgment.—The foregoing is a paper presented at the 8th annual Asphalt Paving Conference, West Baden Springs, Ind., Oct. 28 to Nov. 1.

World's Highest Bridge.—A suspension bridge spanning the Royal Gorge of the Arkansas River near Canon City, Colo., opened to traffic last December, is stated to be the highest bridge in the world. The main span of the bridge is 880 ft. in length, and the bridge is 1,200 ft. long and 1,053 ft. above the bed of the Arkansas River. The roadway is 18 ft. wide and is protected by a guard rail 4½ ft. high. The bridge was designed by George E. Cole and was built for the Royal Gorge Bridge & Amusement Co.

$6,000,000 for Road Work to Relieve Unemployment, Sydney, Australia.—For the immediate relief of unemployment throughout the commonwealth the federal ministry is proposing to make available approximately $6,098,125 in the present financial year for road work in the different states.

The Early Days of Road Building

Some interesting facts regarding the beginning of the "good roads" construction era in this country were given by George C. Warren, chairman executive committee, Warren Brothers Co., in a paper presented Jan. 16 before the American Road Builders Association. The notes following are taken from this paper:

Prior to 1893 there were few country highways in America other than indifferently graded natural soil with side drainage ditches and in a few instances dressing of roadside gravel.

The most general practice by way of road construction and maintenance was to provide a "road tax" and permit taxpayers to "work out" the tax at say $1.50 per day for labor and $3.00 per day for two-horse teams, with scarcely a semblance of system or direction in work done. The result was that in seasons when plowing, planting, haying, etc., were off, the farmers would use their part-idle time in doing something on the roads as near as possible to their farms. Some would plow or hoe up the sod and throw it into the sides of the roads. Others would dig side drains and again throw the excavated material, whether clay, gravel or whatnot, into the road, sometimes filling holes, sometimes just raising the crown and increasing the factors for more mud. Some would haul uncrushed cobbles or field stone from their farms and fill holes in the road. Final result, more mud and rougher surfaced roads.

New York state, for instance, had just passed through the side-road bicycle cinder-path promulgated by Col. Albert A. Pope, the greatest good-road enthusiast of his day, primarily to provide an outlet from city to country for his bicycle production.

Resulting from the untiring efforts of Col. Pope, the Bureau of Public Roads was inaugurated in 1893 through an Act of Congress, which appropriated $10,000 to enable the Department of Agriculture to investigate the condition of the roads throughout the country.

Practically the first asphaltic pavements in New York City consisted of a large mileage on its principal streets and avenues of bicycle strips, being about 3 ft. wide, next to the curb for "smoothing the way," segregating bicycles from the then horse-drawn vehicles for safety and convenience. Now the motor cycles have no segregated area, but with their fiendishly rapid speed, dodge automobile congestion. What changes in a relatively few years!

The Good Roads Act referred to was signed by the President on March 3, 1893, and shortly thereafter General Roy Stone was appointed a special agent to take charge of the work. On January 11, 1899, he was appointed the first "Director of the Office of Public Roads."

In 1893 an organized effort was begun toward better roads in New York state. That year in Utica, N. Y., the "Oneida County League of Good Roads" was incorporated. The writer was a charter member.

Its first meeting was addressed by Gen. Stone to put "fire" into the organization. The burden of Gen. Stone's talk was that for $800 per mile, country roads could be converted into macadam, which would be a panacea of road troubles of the farmer, as well as the urban citizen. General Stone gave assurance that $800 per mile would be ample and cited as proof a recently constructed macadam road in Canastota, N. Y. Of course, it was little more than a thin "shell" of stone over the old dirt road after dragging and shaping. At that time labor and materials cost less than one-third of their present rates. That was the beginning of "good road" construction in New York state. About the same time beginnings were made in Pennsylvania, New Jersey, Connecticut and Massachusetts. These first results were poor and entirely inadequate, but had the useful effect of a temporary object lesson and improvements soon followed.

In 1899 limited appropriations were made by the state of New York for macadam road construction. One of the first of these roads was in Oneida County between Herkimer and Little Falls, in which the hard limestone used was produced by the Warren-Burnham Company, of which the writer was general superintendent in connection with the hydro-electric power development contract at Trenton Falls, N. Y., for the Utica Electric Light and Power Co. The demand for these improved macadam roads rapidly extended and soon a $50,000,000 bond issue was passed by the New York state legislature. Then began the real, live "good roads" construction development in New York and other states.

Mexico Prepares for Third National Highway Congress and Exposition.—The call for the third Mexican National Highway Congress will soon be issued. The congress will be held during the month of April, 1930. An exposition and demonstration of highway equipment will be held in connection with the congress. In view of the experience that Mexico has obtained during the course of the preceding highway congresses, and the rapid headway that Mexico is making in highway construction, it is expected that the third congress will be largely attended.

New Telephone Service on Rome-Ostia Highway.—The Rome-Ostia automobile highway which was inaugurated last year, has the most intense motor traffic in the vicinity of Rome. For the convenience of motorists who may need assistance en route a special public telephone service with eight apparatus has been established along the highway.

Treatment of Subgrades with Bituminous Materials

The Theory of Subgrade Stabilization, Its Practical Application and the Function of Bituminous Treatments with Respect to Stage Construction

By C. A. HOGENTOGLER and HENRY AARON

Senior Highway Engineer, U. S. Bureau of Public Roads, and Junior Civil Engineer, U. S. Bureau of Public Roads

IN order to thoroughly comprehend the discussion to follow, one has only to remember that during either increase or decrease of the volume of the soil mass due to change in moisture content or to change in degree of consolidation, only the void volume or pore space changes, the volume of the soil particles remaining constant.

Either bituminous or other types of treatment may prove beneficial if they serve to increase the stability of subgrades. And stability or the resistance furnished by subgrade soils to flowing laterally depends upon the two mechanical properties:

(a) Internal friction, or that portion of the resistance to shear which is dependent upon the external force applied, and

(b) Cohesion, or that portion of the resistance to shear which is independent of the external force applied.

The significance of the term internal friction is illustrated by the performance of two pieces of sand paper when pressed together. Under these conditions they exert no resistance to being pulled apart. They exert resistance to sliding over each other, however, dependent upon the pressure with which they are pressed against each other.

The significance of the term cohesion, is illustrated by the performance of two pieces of flypaper when pressed together. Under these conditions they exert high resistance to being pulled apart, due to stickiness or cohesion possessed by glue like materials brought in contact with each other. The resistance which the pieces of flypaper exert to resist sliding over each other is furnished by surface stickiness instead of surface roughness, as was furnished by the sand paper.

Influence of Internal Friction and Cohesion on Stability.—When a soil flows latterly, whether it pushes out from beneath a pavement edge or up into the interstices of a macadam, sliding occurs along either one plane or more planes existing in the soil. Furthermore this sliding occurs only because the force which produces sliding exceeds the shear resistance existing in the soil along the sliding plane or planes.

Assume, for instance, that the line CD (Fig. 1) represents any plane in the soil upon which a unit soil weight w is acting. A unit shear resistance t acting along the plane CD holds the soil (weight w) in equilibrium and prevents it from sliding.

The shear resistance t is composed of two parts: That furnished by the resistance of the soil grains to sliding over each other (sandpaper effect) and that furnished by the cohesion (fly-

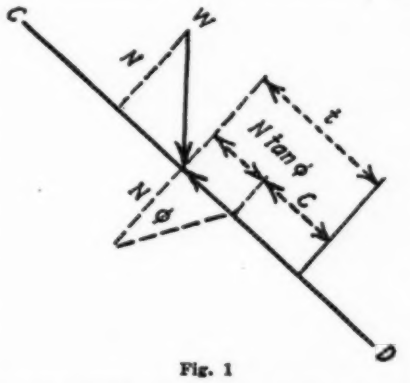


Fig. 1

paper effect) existing between the soil particles. The resistance to sliding is dependent upon the angle of internal friction Φ: that angle whose tangent equals the frictional resistance divided by the pressure normal to the sliding plane. The cohesion existing between soil particles is designated as cohesion in pounds per square foot, kg. per sq. cm., etc., existing between soil particles.

When

Φ=angle of internal friction.

N=component of w, normal to CD.

t=N tan Φ+C.

On this basis the Bureau of Public Roads, in its publication, "Public Roads," Vol. 10, No. 3, May, 1929, suggested a formula by means of which some conception could be obtained with respect to the influence exerted by both internal friction and cohesion upon stability.

Increasing Stability of Clays.—According to Table I, the stability of clays may be increased enormously by reducing their moisture contents. Furthermore the stability of wet clays may be very appreciably increased by mixing sand with them and the stability of sands may be very greatly increased by mixing clay with them.

The supporting value of sand, for instance, possessing no cohesion and internal friction in amount represented by Φ=34°, is 768 lb. per square foot. The supporting value of soft clay possessing cohesion in amount equal to 400 lb. per square foot and internal friction in amount represented by Φ—4°, equals 1,857 lb. per square foot. These two materials properly combined, however, are apt to furnish support exceeding in amount 6,000 lb.

By use of the formula referred to above it can be demonstrated also that with equal cohesion furnished by the clay, the stability of the subgrade increases with increase of internal friction furnished by the sand and for equal internal friction furnished by the sand the stability of the subgrade increases with increase of cohesion furnished by the clay.

Thus, for instance when the cohesion equals 400 lb. per square foot the supporting value of the subgrade will equal either 3,070 or 14,503 lb. per square foot, depending on whether the angle of internal friction equals 12° or 34°. And when the angle of internal friction equals 34° the supporting value of the subgrade will equal either 11,089 or 24,745 lb. per square foot, depending on whether the cohesion equals 200 or 1,000 lb. square foot.

According to available information, sands possess a relatively high degree of internal friction. The greater the

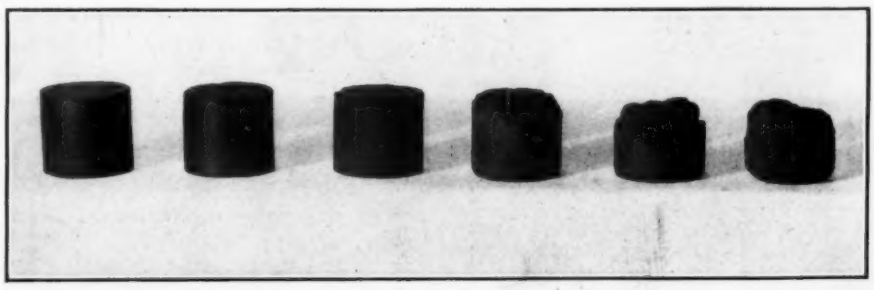


Fig. 2—Soil Cakes; Two Cakes at Left Contain Tar in Appreciable Amounts; Third Cake Contains Small Amount of Tar; Fourth Cake Contains a Trace of Tar; Two Cakes on Right Contain No Visible Trace of Tar

Road Constructed of Stable Sand-Clay Mixture

degree of angularity, sharpness or roughness possessed by the sand grains the greater is apt to be degree of internal friction furnished by the sand. Silts possess internal friction in amount varying between $\Phi=10°$ and $\Phi=30°$, depending upon the moisture content of the soil. Silts possess practically no cohesion. Clay and colloids furnish cohesion but possess internal friction in relatively small degree.

What Admixtures May Do.—Practically this information suggests that:

1. Admixtures which serve to prevent the soil from taking up moisture serve to prevent the soil from losing cohesion and therefore should serve to increase the stability of clays when used either as binders or subgrades.

2. Admixtures possessing cohesion should serve to furnish cohesion additional to that possessed by the soil. Admixtures of this type therefore should serve to increase (a) the stability of cohesionless silts when used either as binders or subgrades and (b) the stability of sands when used as subgrades.

3. Admixtures of granular materials possessing high resistance to sliding are apt to furnish stability in much greater amount than admixtures of granular materials possessing relatively small resistance to sliding.

Soils may become wet, due to water furnished by seepage, capillarity or frost action.

Water furnished by seepage must be intercepted and removed by artificial drainage.

Capillarity Due to Surface Tension of Water.—The capillary pressure which forces water up through the soil pores is the same force surface tension which drives water up into a capillary tube. When the surface tension equals 75 dynes per cm. (water temperature slightly above 0°C.) and when r equals the radius of the capillary tube in cm. the maximum theoretical capillary rise

$$\text{h in cm. equals } \frac{0.1531}{r}.$$

Accordingly the height of capillary rise would be expected to increase as the soil particle diameter decreases. Thus in a tube 0.01 cm. in diameter water would be expected to rise to a

$$\text{height of } \frac{0.1531}{0.005} = 30.6 \text{ cm.}$$

and in a tube .001 cm. in diameter water would be expected to rise to a height of 306 cm.

As a matter of fact the maximum theoretical height of capillary rise indicates the pressure which tends to force water into the soil, and while this force increases as the size of the soil particles decreases, the total frictional resistance exerted by the walls of the capillaries to prevent capillary rise increases as the particle size decreases.

Silts are apt to possess this proper combination of forces productive of important capillary rise. Dense clays, in contrast, when the ground water elevation is low, are not apt to suffer detrimental capillary rise.

Furthermore, laboratory experiment has demonstrated that (a) the capillary rise in soils when wet may equal as much as five times the height of the capillary rise in the same soils when dry, and (b) capillary moisture cannot enter soil pores containing either air or water until after the contained air or water has been driven out.

Effect of Admixture on Capillarity.—Practically, these facts suggest:

1. Admixtures of materials which serve to reduce the size of the soil pores should be effective for reducing the effective height of capillary rise in silts.

2. When the top soil is fairly dry to some distance below the ground surface, water sprinkled on the subgrade is apt (a) to enlarge the pores of the top soil and (b) to penetrate into the under soil. Consequently bituminous material applied after the water has soaked into the soil, is apt to penetrate more readily and to a greater depth than when applied on the thoroughly dry soil. Wetting the soil in this case is similar in principle to wetting a blotter prior to attempting to absorb a drop of ink.

3. Admixtures such as hydrated lime, for instance (as suggested by Mr. Lang), which serve to enlarge the pore size in soils is apt to increase the depth of soil penetrated by bituminous materials.

4. An impervious covering applied on the surface of the subgrade when the ground water elevation is low should serve to retard the rate of the escape of air entrapped in the soil and consequently should serve at the same time to reduce to some extent the rise of capillary moisture into the subgrade soil.

Expansion Depends Upon Both the Capillary Properties and the Degree of Cohesion Possessed by the Soil.—In order that soils may expand and soften, due to capillarity, water must enter the soil pores and push the soil grains apart. While the capillary moisture entering the soil attempts to push the soil grains apart, the cohesion existing between the soil particles attempts to prevent them from being separated. Consequently when the cohesion possessed by the soil either equals or exceeds the force exerted by capillary pressure to push the soil grains apart, the soil cannot expand, water cannot enter the soil and as a result the degree of cohesion possessed by the soil is not reduced in appreciable amount.

Wet compressed soils are apt to expand in less degree than the same soils when dry and soils containing both clay and colloids of the glue type are apt to expand and soften in less degree than soils which do not contain these constituents.

Thus water due to capillary pressure is apt to enter cohesionless silts rapidly and push the silt grains apart to such an extent that the soil quickly disintegrates. Irrespective of the fact that water is apt to flow faster through wet, than through dry silts, water is apt to cause wet compressed silts to expand at a slower rate than thoroughly dry silts. Therefore wet silts will not suffer disintegration as quickly as the dry silts. Plastic soils (those possessing cohesion (when dry may or may not absorb moisture in amount sufficient to cause disintegration, depending upon the amount of gluey colloid contained in the soil. Wet compressed plastic

soils are not apt to disintegrate due to water absorption unless they are manipulated.

Each of 90 soil cakes, for instance, were compressed in the wet state in the subgrade laboratory of the U. S. Bureau of Public Roads, under a load equal to 3 Kg. per sq. cm. The load was then reduced to 0.28 kg. per cm. and the cakes were permitted to absorb water. Subsequently two disks, 1 sq. in. in area each, were cut from each of the 90 soil cakes. One of these disks in the wet state was immersed in water and its counterpart was first allowed to dry to constant weight in the air and was then immersed in water.

Eight of the 90 disks containing clay less than 12 per cent immersed in wet state disintegrated after being immersed for times averaging 73 days. Of the eight corresponding disks immersed in the dry state six disintegrated after being immersed for an average period of seven minutes and the remaining two swelled and cracked in appreciable amount but did not completely disintegrate after being immersed for a period of 25 days. Sixty-eight of the 90 disks containing with several exceptions clay 13 to 77 per cent, immersed in the wet state have not suffered disintegration after being immersed for an average period of nine months. Of the corresponding 68 disks immersed in the dry state, 26 disintegrated after being immersed for an average period of 10 minutes, 41 disintegrated after being immersed for an average period of one hour and with few exceptions the remaining disks cracked and swelled in appreciable amount after being immersed for an average period of 10 days.

As additional evidence that cohesion in soils is apt to prevent both their expansion and disintegration due to water absorption reference is made to Fig. 2. The soil cakes shown here represent soil existing at different depths in a subgrade located at Arlington, Va., treated with water gas tar in 1923.

These cakes were immersed in a semi-dry state, dried to constant weight in the air and immersed in water for a period of two weeks. The two cakes shown on the left of Fig. 1 contain tar in appreciable amount and exhibit no signs of disintegration. The third cake from the left contains but a small amount of tar and has suffered crumbling in slight degree along the top edges. The fourth cake from the left contains but a slight trace of tar and shows crumbling in appreciable amount near the top. The two cakes on the right contain no visible trace of tar and have suffered crumbling in advanced degree.

Of ten concrete slabs constructed at Arlington in 1923 in connection with the drainage experiments, all, according to Dr. E. C. E. Lord, check cracked except the one laid on the tar treated subgrade referred to above.

Practically this information suggests:

1. Admixtures possessing cohesion are essential to prevent silts from losing stability due to water absorption.

2. Clay soils when compressed in the wet state are not apt to lose stability due to water absorption unless manipulated.

3. Neither clays nor silts when treated with materials possessing cohesion in high degree are apt to lose stability due to water absorption when either wet or dry.

Frost Heave Apt to Be Important in Permeable Silts.—Briefly, ice segregation is due to three physical phenomena:

(a) The ability of water particles contained in soil pores larger than about capillary dimension to freeze at either normal freezing or slightly less than normal freezing temperatures (—1°—4°C).

(b) The ability of water particles contained in soil pores of capillary dimension to resist freezing at abnormally low temperatures (as low as —70°C).

(c) The ability of water particles of freezable size, during the process of freezing to draw to themselves from adjacent fine capillaries the small particles of water which individually do not freeze at ordinary freezing temperatures. When drawn to the existing ice crystal, however, these small water particles freeze and increase the size of the original ice crystal. Continuation of this process causes the original ice crystals to increase in size as long as they are being furnished small water particles drawn up through the fine capillaries from the ground water supply.

In sands no important frost heave occurs because practically all of the contained water freezes at normal freezing temperatures and small unfrozen water particles do not exist in amount sufficient to cause the frozen particles to suffer appreciable growth.

Permeable silts which are capable of raising water rapidly and through distances of considerable amount, are apt to suffer very important frost heave. These silts may be capable of raising by capillarity at the rate of approximately 0.9 lb. of water per square foot of soil per day when the ground water elevation is 4 ft. below the surface of the ground. At this rate a layer of water approximately 5½ ft. in depth would be raised during one year. In fact, an average corn crop in the middle west for average yield may require capillary water to be supplied at approximately this rate.

The capillary rise may be as high in cohesive clays as in silts. The speed with which water rises in clays, however, is much less than in silts. Consequently, in dense clay soils with low ground water level and absence of lateral seepage, only limited amounts of water are available for ice segregation. Under these conditions the soil adjacent to the growing ice crystals is apt to dry out and shrink due to the loss of moisture. The ground water elevation in clays, therefore, must be comparatively high in order that important frost heave may occur. Or the clay must be wet due to water absorption with manipulation on top of the subgrade.

Additive to the detrimental effects of heaving is the softening of the subgrade during thaws due to the liberation of excessive amounts of water trapped by both frozen under-soil and frozen shoulders.

Due to a variety of causes frost depth under runways is apt to be greater than under shoulders. Also thawing is apt to occur first under the roadway; therefore, water liberated in this manner

View Showing Road Constructed in Cohesionless Sand

cannot penetrate the frozen soil along the edge of the runway and reach the drain located there. Thus the drains must be placed at the location of maximum frost depth which is apt to coincide with the location of initial thawing. In this respect the center drain, according to Henry Aaron, U. S. Bureau of Public Roads, and L. L. Allen, Minnesota State Highway Department, serves (a) to lower the moisture content of the soil before freezing and (b) to provide for the disposal of water liberated by thaws.

Especially important with respect to frost heave (according to W. I. Watkins, U. S. Bureau of Chemistry and Soils, E. A. Willis, U. S. Bureau of Public Roads, and John Morton, New Hampshire State Highway Department) are soils consisting of sand to a depth of as much as 12 or 18 in. underlain with silt zone which sag and permit water to accumulate.

Practically this information suggests that:

1. Any admixture which serves to reduce the moisture content possessed by the subgrade soil is apt to reduce the extent of frost heave.

2. Any treatment which serves to prevent water entering the subgrade from above may serve at the same time to prevent increase in the moisture content of the subgrade to depths depending upon the permeability of the subgrade soil. Consequently a treatment of this character may serve to reduce the extent of frost heave suffered by the subgrade due to water absorption from above.

3. Any admixture which serves to furnish cohesion in silts is apt to reduce also the extent of frost heave suffered by subgrades consisting of silt.

4. Drains backfilled with porous material placed longitudinally under the center of gravel road surfaces, and in depth slightly greater than the depth of frost penetration should serve to (a) reduce the extent of frost heave in silts by reducing the moisture content possessed by the soil before freezing and (b) prevent loss of stability in silts by disposing of water liberated during thaws.

Practical Application of the Theory of Subgrade Stabilization.—According to laboratory experiment and theory, therefore, bituminous treatments should prove beneficial provided they serve

(1) To reduce the moisture affinity possessed by soils;

(2) To furnish cohesion in soils;

(3) To provide an impermeable coating which prevents both water resting on top of the subgrade from penetrating the top layer of the subgrade and the escape of air through the top of the subgrade, whereby capillary moisture is permitted to enter the subgrade from beneath.

That bituminous materials possess cohesion is admitted and as a consequence they must of necessity furnish cohesion in soils and as a result serve to reduce the moisture capacity in that portion of the soil penetrated by the bituminous material.

Furthermore, it must be admitted that bituminous materials may serve to furnish an impermeable coating on subgrades, provided either the layer of bituminous material or the layer of penetrated soil be thick enough.

Consequently one must investigate the thickness required to furnish the particular benefit desired.

The Function of Bituminous Subgrade Treatments with Respect to Stage Construction.—In this case, granular material, sands, slag, gravel, crushed stone, etc., applied in layers varying in thickness (1 to 4 in.) is maintained under traffic. New material is added to fill up road surface depressions when they occur.

According to H. J. Kirk, formerly Director of the Ohio Department of Highways, a total thickness of granular material equal to 8 in. (applied in two layers each 4 in. thick), when compacted by traffic, furnished in the resulting road surface a stability greatly exceeding that furnished by an equal thickness of mineral aggregate applied or compacted in any other way.

During the compaction of this granular material the soil which originally composed the top layer of the subgrade becomes the binder which furnishes the cohesion necessary for stabilizing the resulting road surface. Therefore, in this case, the depth of treatment must equal the thickness of soil which becomes the binder of the traffic-bound road surface.

If it may be assumed that the layer of stone 8 in. thick originally compacts to a layer 6 in. thick when stabilized; and furthermore, if the compacted layer may be assumed to possess a porosity equal to 25 per cent, the thickness of top subgrade soil which becomes binder equals about 1½ in.

But according to previous discussion the thickness of the road surface containing a treated binder, to render equal service, would of necessity be less than that required by a road surface in which the binder is not treated. How much less in thickness the traffic bound road should be when the binder is treated than when it is not we do not at present know. We do know, however, that increasing the roughness, or the angularity of the granular material serves to reduce very appreciably the required thickness of the road surface. According to Raymond Smith of the Ohio Highway Department, for instance, the reduction in the total thickness of granular materials required to effect stabilization may be very appreciable during a period of several years due to difference in both the roughness and the angularity (internal friction) possessed by the individual granular fragments.

Therefore, it is possible (according to theory) that the increased minimum cohesion furnished by treating a binder may serve also to very appreciably reduce the required thickness of the road surface.

If, perchance, a thickness of consolidated stone equal to 4 in. proves adequate when the soil is treated, the depth of treated soil should equal about 1 in.

If for sake of demonstration it may be assumed that an admixture equal to 5 per cent will serve to furnish reduced water affinity in clays or increased cohesion in silts in required amounts, ½ gal. of admixture per square yard will be required, provided the soil dust weighs 100 lb. per cubic foot and the admixture weighs 8 lb. per gallon. The binder in this case must of necessity be one which penetrates the soil.

The resulting traffic bound road in this case when surface treated becomes

(1) A road surface which has been thoroughly tested by traffic for the existence of weak areas.

(2) A highly compacted combination of mineral particles bound together by a treated material from top to bottom.

(3) A waterproof, impervious covering which should serve to prevent water penetrating the subsoil from above and capillary moisture entering into impervious soil from below.

When these treatments on silts not subjected to frost action and on clays are supplemented by drainage to intercept seepage; and when those treatments on silts subjected to frost action are supplemented by drainage to both intercept seepage and reduce the extent of the detrimental effects of frost heave, the maximum support to be furnished by a stable impervious wearing course bonded homogeneously into a subgrade protected as much as possible from softening is obtained.

The Function of Bituminous Subgrade Treatments with Respect to the Construction of Macadam Pavements.—Primarily the failure of macadams on other than elastic subgrades is due to the subgrade soil penetrating the interstices of the macadams. In order that this may occur (a), the subgrade soil must be wet and (b), voids in appre-

Table 1—Values of c and ϕ for Different Soils and Their Influence Upon the Supporting Value, q for Several Assumed Conditions (b=0.71 Ft. and s=100 Lb. Per Square Foot)1)

Soil	Cohesion, c, pounds per square foot	Angle of internal friction, ϕ Degrees	Supporting value, 1) q, pounds per square foot
Clay, almost liquid..	100	0	400
Clay, very soft.....	200	2	864
Clay, soft	400	4	1,857
Clay, fairly stiff.....1,000		6	4,982
Clay, stiff 1,500		8	8,050
Clay, very stiff.....2,000		12	12,528
Silts, wet 2).....	0	10	43
Sands, dry	0	34	768
Sand predominating with some clay.....	400	30	6,035
Sand-gravel mixtures, cemented 3).....1,000		34	17,838

1) The values of q serve for demonstration purposes only and should not be used as a basis of pavement design.

2) In silty soils, the angle of internal friction may vary between 10 and 30 degrees, but the cohesion may be almost 0.

3) In properly graded soils, depending upon the extent of their compaction, the angle of internal friction may exceed 34° and the cohesion may be considerably less than 1,000

ciable amount must exist in the under course of the macadam.

Applying bituminous material on the subgrade and covering with a cushion of granular material before constructing the macadam, supplemented by drainage as specified for stage construction, is suggested to prevent failure of this character.

Sands are not apt to work up into the interstices of macadams. Treating sands with bituminous material, however, is apt to increase their supporting value to such an extent that an appreciable reduction in pavement thickness will be permitted. Stabilization of this character is apt to be furnished by all bituminous materials possessing high penetrative properties. The depth of penetration may equal 1½ or more inches.

The treatment on clays is to furnish an impervious coating and the only requirement with respect to the depth of soil to be penetrated is that the impervious top coating of bitumen shall be well bonded to the subgrade soil. A bond of this character may be furnished by depth of penetration equal to ⅛ to ⅜ in.

The procedure is as follows:

On the thoroughly consolidated subgrade apply the bituminous material and cover with a blotting layer of granular material

The proper amount of bituminous material to be applied is not definitely known but probably varies between ⅜ and ¾ gal. per square yard.

Apply blotting material at the rate of about 100 cu. yd. per mile for a treated roadway width equal to 24 ft. The macadam may be constructed upon this treated subgrade immediately or the treated subgrade may be used as a low cost road surface for a period of time.

Prior to constructing the macadam, spread the stone screenings, granulated slag, etc., on the treated subgrade, in thickness not exceeding about one-fourth the depth of the thickness of the macadam course. On this spread the stone course of the macadam and proceed with the construction in the regular manner.

Why these skin treatments on clay subgrades may furnish benefit equal to that furnished by foundations of appreciable thickness is apparent.

Clay soil, until after it flows laterally, can not penetrate the interstices of the macadam. Clay soil can not flow laterally until after it has attained very low cohesion due to water absorption. Clay soil in the plastic state can not absorb water when present unless the clay is manipulated. The clay skin, in contact with the bottom stones of the macadam must be manipulated and softened before the subgrade soil below this treated skin can be enabled to soften. The water which is apt to cause this upper skin of an impervious clay soil to soften must of necessity be water resting on the surface of the subgrade and trapped in the interstices of the macadam. The bituminous treatment prevents this water from both coming in contact with and softening the subgrade soil. The mineral binder serves to fill the voids in the macadam.

Consequently, this subgrade treatment serves

(1) To eliminate the voids into which the clay would enter.

(2) To eliminate the voids in which water would collect on top of the subgrade.

(3) To prevent water resting on top of the subgrade from both entering and softening the subgrade soil.

View Showing Road Constructed in Frictionless Clay

Just how much benefit subgrade treatments of this character are apt to furnish is not known at present. It is possible, however, that on subgrades treated in the manner described, flexible pavements not more than 3 or 4 in. thick will prove adequate to carry heavy traffic on sand and similar pavements not more than 6 or 8 in. thick will prove adequate to carry heavy traffic on properly drained clay and silt subgrades other than of the elastic varieties. When the presence of colloids in appreciable amount in the subgrade soil require the construction of extra thick foundations under flexible pavements and when porous base courses are used under concrete pavements, the bituminous treatment of the subgrade still remains an essential requirement.

Results Furnished by Subgrade Treatments in Practice.—It is hoped that a report of a comprehensive investigation of stabilization of subgrades carried on in Ohio by both Raymond Smith and Professor F. H. Eno will become available during the coming year.

A report of a comprehensive investigation of subgrade treatments carried on by the U. S. Bureau of Public Roads, with the U. S. Bureau of Chemistry and Soils and the State Highway Departments of both Minnesota and Missouri cooperating, is now being prepared. Little of authentic character can be said until those reports become available.

The benefits which are apt to be furnished by subgrade treatments are indicated, however, by the following:

(1) Bituminous coating with blotting layer of sand prevents the annual loss of silt 4 to 5 in. thick from roadway adjacent to a concrete pavement 9 ft. wide in Missouri. (According to J. J. Corbett, District Engineer of the Missouri State Highway Commission, St. Joseph, Mo.)

(2) Subgrade treatment with bituminous material covered with gravel 2 to 4 in. thick furnishes a road surface equal in efficiency to a road surface consisting of gravel 8 in. thick constructed on an untreated subgrade in Missouri. (According to F. V. Reagel, Missouri State Highway Department.)

(3) Bituminous coatings covered with blotting layers of granular material furnish all-year serviceable roads in the Red River Valley, located in both Minnesota and North Dakota (Gumbo soil), whereas gravel surfacing on untreated subgrades fails in locations where surface water in adjacent fields causes the subgrade soil to become wet.

(4) Subgrade treatments of tar paper serve to prevent cracking in concrete pavements due to certain subgrade soils absorbing water from the concrete when setting. (According to R. W. Crum, Director of the Highway Research Board.)

(5) A subgrade treatment consisting of ¼ gal. of bituminous material to the square yard and a blotting layer of 112 cu. yd. per mile on a roadway 30

ft. wide at a cost of about $500 per mile furnishes better service, produces less dust and has a lower maintenance cost than gravel applied at the rate of 500 cu. yd. per mile, at a cost of $800 per mile, on untreated silts, in St. Louis County, Minn. (According to Sheldon B. Shephard, County Engineer of St. Louis County.)

Conclusions.—It should be emphasized in conclusion, however, that

(1) Subgrade treatments not supplemented by adequate drainage do not serve to prevent loss of stability in silts during the spring thaws.

(2) Treating merely the surface of subgrades does not serve to eliminate the detrimental elasticity possessed by soils containing either mica or organic matter in appreciable amounts.

(3) Bituminous subgrade treatments used under top soil roads might serve to trap water entering the top of the road surface and thus might cause the top soil road to soften.

(4) Subgrade treatments essentially are not permanent road surfaces. Therefore, to utilize the full benefit to be derived from subgrade treatments, an attempt should be made to construct upon them (possibly progressively) road surfaces permanent in character.

(5) Admixtures of bituminous materials combined with both intensive subgrade manipulation and chemical admixtures furnish a fruitful field for investigation.

(6) Proper methods of application, amounts of material to be applied and types of bituminous materials best suited to furnish the desired results remain to be disclosed by research to be performed in the future.

(7) A thorough understanding of the physical laws upon which the serviceability of subgrades depends serves to disclose the possibilities to be furnished by research of this character. Furthermore, those physical laws furnish a basis according to which research yielding fruitful results may be intelligently performed.

Acknowledgment.—The foregoing is a paper presented at the 8th Annual Asphalt Pacing Conference.

West Virginia Protects Roadside Flowers.—The West Virginia Department of Public Safety has ordered all policemen and state troopers to lend every reasonable effort to enforce the law enacted at the recent session of the legislature against the plucking of flowers along the highways. The new law prohibits the picking of flowers within 100 yd. of a highway without the written consent of the owners of the land on which they grow, and transportation of wild flowers and shrubs is also prohibited. The law provides a penalty of $100.

Labor Organization for Concrete Road Construction

In a report submitted by the delegation from the United States to the Second Pan-American Highway Congress (Rio de Janeiro, Aug. 16-23, 1929) it was stated that studies by the U. S. Bureau of Public Roads indicates that the minimum personnel required per mixer, for efficient operation in concrete road construction, omitting truck drivers (these vary with the haul) is as follows:

	No.
Rough grading:	
Grade foreman	1
Plow holder	1
Teamsters	2
Fine grading:	
Tractor operator	1
Blade operator	1
Roller operator	1
Subgrade operator	1
Laborers	2
Handling forms:	
Foreman	1
Teamster	1
Laborers	5
Handling materials:	
Batching plant foreman	1
Crane operator	1
Hopper operator	1
Cement handlers	3
Bag baler	1
Pump operator	1
Laborers on pipe line	2
Turntable operator	1
Truck dumper	1
Laborer	1
Hauling materials:	
By truck—	
Mechanic	1
Helper	1
Mixing:	
Mixer operator	1
Finishing and curing:	
Puddlers	2
Finishing-machine operator	1
Concrete finisher	1
Laborers to spread burlap	2
Laborers to spread earth	2
Laborer to sprinkle concrete	1
Miscellaneous:	
Superintendent	1
Timekeeper	1
Watchman	1
Water boy	1
Total without truck drivers	46

On 22 projects studied by the U. S. Bureau of Public Roads, the number actually employed varied from 35 to 90, with an average of 53.

Experimental Oil Treated Road in California

The Division of Highways of the California Department of Public Works and the U. S. Bureau of Public Roads, early last fall, started cooperative construction of a 10-mile experimental section of low cost type of oil-treated road surface on the Truckee River Highway between Boca and the Nevada state line west of Verdi. The bureau is also joining in the cost of maintaining this work for a three-year period. The work is to be watched closely during this period and a careful record kept of both the construction and maintenance methods and cost, as well as the service obtained from the several combinations of materials.

The work is divided into 20 sections, each ½ mile in length. Eight of these sections was covered with 4 in., loose measure, of ¾ in. to dust crushed rock. These eight sections are to be bound up under traffic during the coming winter and their treatment by penetration and sealing with various grades of asphaltic oil will be taken up next year. The remaining 12 sections are to be surfaced with ¾-in. crushed rock and gravel with and without fines. This material will be bound up immediately with various grades of fuel and asphaltic oils. Two of the oil mixed sections will be sealed before winter. The sealing of the remaining oil mixed sections will be determined by their actions under weather and traffic conditions.

The Truckee River road was selected by the bureau as being best suited for the experiment. The location provides a winter climate with snow and frost and a summer climate fairly typical of a dry region. The traffic of nearly 1,400 vehicles on peak days is sufficient to be a severe test for the type of road surface. The road was constructed in 1925. In 1926 part of the section was surfaced with 3 in., loose measure, of crushed rock and a portion was surfaced with a 4-in. thickness of volcanic cinders. This material was oil mixed in 1927. This limited surfacing with constant maintenance has given fairly satisfactory service during the past two years, but it is now disintegrating.

Seek Lightweight Concrete for Floors of Long Bridges

Highway engineers of the U. S. Department of Agriculture are conducting experiments which involve improvements in quality of concrete in floor slabs of bridges and possible advantages to be gained by the use of lightweight concrete in floors of long-span bridges.

The tests are being conducted at the experiment farm, Arlington, Va., under a cooperative arrangement between the Bureau of Public Roads and the Port of New York Authority.

The experiments at Arlington Farm embrace the construction of 22 concrete slabs, each 6 ft. wide and 22 ft. long, with materials and methods such as might be used in the construction of bridge floors. Different aggregates were used, including one of light weight which resulted in a concrete weighing only about two-thirds as much as the ordinary product. Different vibratory methods were employed in placing the concrete for the purpose of increasing its density and thereby improving its quality. The large slabs were subsequently cut up into smaller pieces of sizes suitable for testing.

The program also includes tests to determine the strength of plain and reinforced slabs, the bond strength of embedded steel, and the density, durability, and elastic properties of the concrete. The data thus far available indicate that information of considerable value to highway engineers will be obtained.

Reflections on the 1930 Road Show

Committee Meetings Well Attended—Many Improvements Noted

ANOTHER road show and convention of the American Road Builders' Association has become history. Reflecting on the various incidents and experiences occurring at it one is led to the conclusion that even though the attendance was considerably short of past exhibitions there was a better caliber of visitors as a whole. In fact, the 1930 exhibition was the best show held by the road builders' association since 1929. In general, it may be said that the arrangement of exhibits was much better than at prior shows because the two floors of the big auditorium contained all but the heavy locomotive and truck mixer exhibits.

A remarkable improvement in the convention sessions was noted. The committee rooms provided were too small, even as divided, to contain those desiring to attend. In some of the committee meetings interest lagged because prepared papers were read in full. Better results could have been obtained had these papers been just briefly sketched, verbally, by their authors and more time have been devoted to discussion. Committee work was so well divided and so well regulated that it was impossible for one to attend all meetings. For this activity the association staff should be duly credited. Undoubtedly a great economic benefit will be derived by the people at large from these meetings.

A convention or congress and exposition of this type is of considerable economic value to the taxpayer at large. It is true that state highway officials have a closed door convention of their own for the discussion of highway problems, it is also true that several sectional road and highway conferences are held each year. These are all beneficial, yet they do not have the weight, bearing and value of a national organization in which all phases of highway problems are analyzed. In the committee meetings of this organization newer methods of construction and design are discussed, obsolescene of specifications are investigated with the purpose in view of suggesting changes for uniform adoption nationally. Many of our specifications are unable to economically govern work because of the rapid advance of improved machinery and equipment. These specifications should be revamped. Quite a substantial percentage of saving in expenditure can be made by writing specifications in such a way as to employ modern equipment.

Another field, quite new and one in which varied standards and ideals are at work, is that of highway location, or relocation. Why one location engineer does one thing may be quite different from why another equally qualified location engineer would do the same thing. By general discussion of this common problem it is expected that certain practices will develop which will be recognized, nationally, as good practice. This problem of highway location is wrapped up with public relations as well as engineering design. By employing the good practice standards which will surely develop from these nation-wide conferences the taxpayer in general will receive a dollars and cents saving in his annual highway bill.

These are but two of the many fields of investigation delved into by the American Road Builders' Association. Specifications are written by engineers with the purpose in view of specifying a desired result of some construction operation. There may be various ways and means of accomplishing the specified result. The purpose of the contractor who bids on the specified work is to construct the job at the least possible cost and yet obtain the desired or specified result. To accomplish this purpose he employs various types of machinery and equipment as well as hand labor. This fact then calls into play the activities of materials, equipment and machinery manufacturers.

Hence, the annual Road Show serves an economic benefit to the taxpayer at large because it affords a common meeting ground for engineer, contractor and manufacturer. In the meetings, new equipment and economic employment of present equipment can be fully discussed and the information obtained be made available for national distribution. The exposition should not become so highly commercialized as to cause manufacturers to fail to exhibit. There seemed to the writer to be a certain amount of undercurrent of discontent on this point. If commercialism should dominate the promotion of the Road Show, the exposition will soon lose its beneficial economic power and thus defeat the purpose for which it was established. Careful thought should be given to this phase of the annual event by directors of the road builders' association.

In general, improvements on existing equipment was more the nature of the exhibits than display of new materials and machinery. There was, however, quite a few pieces of strictly new equipment. The tendency toward automotive type of construction which evidenced itself last year was carried to further detail. The whole show had a more businesslike attitude than previously. These are simply the reactions of the editor as he perambulated from booth to booth or from one committee room to another after his own committee work was done.

The auditorium is located on the famous Atlantic City boardwalk. While the show was in progress for most of the week the weather was rainy and foggy, except for the last day, when cold weather and a snow set in. It is believed that this was really beneficial weather, so far as the exhibitors were concerned.

One of the usual high lights of these conventions is the annual road builders' banquet. This particular function was not up to par with the rest of the event. Programs mailed out prior to the opening stated that the banquet, which was held at the Ambassador Hotel, would be given at 7:00 p. m. Programs distributed at the convention had the banquet time stated at 7:30 p. m. However, it was 8:25 before it got under way. This would not have been so bad had everybody been placed within hearing of the music and the speakers. Many tables had less than half the places occupied and were in separate rooms from the speakers. The result was that as soon as the cigars were passed those not in the central room did not remain for the speaking. An event which was expected to promote sociability and acquaintance defeated its purpose by scattering guests in twos and three throughout the various hotel rooms and foyers.

Taken all in all it may be said that the 1930 convention and road show of the American Road Builders' Association was commercially advantageous to exhibitors and undoubtedly of value through its committee work to the American public.

Milan-Turin, Italy, Autostrada Construction Contract Signed.—U. S. Consul Homer Brett, Milan, Italy, reports that on Nov. 30, 1929 the contract for the financing of the Milan-Turin Autostrada was signed in the office of the Minister of Public Works in Rome. According to this contract the cost of construction, estimated at $7,631,579, is to be paid one-third by the national government of Italy, one-third by the company out of the capital and the other third is to be raised by the sale of bonds guaranteed by interested municipalities and by the provinces of Milan and Turin. The company's income will be derived from vehicle tolls and advertising. The new autostrada will be 81 miles in length and work on the roadbed will be begun at once as the contract with the government stipuates that it is to be opened to service on Oct. 28, 1932. The Milan-Turin autostrada will be the western trunk of a system which will skirt the southern foot of the Alps all the way from Turin to Trieste.

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Announcing "Motive Power," the Sixth Magazine of the Gillette Group

Twenty-four years ago last month the first of the Gillette Group of magazines was launched, namely "Engineering and Contracting." A sixth number, "Motive Power," now joins this group. In the order of seniority the group consists of:

Engineering and Contracting.
Roads and Streets.
Water Works and Sewerage.
Tiles and Tile Work.
Motor Freight.
Motive Power.

Each of the six is a highly specialized magazine, and, with one exception, each is the circulation leader in its specialized field.

"Motive Power" does not attempt to cover the broad field of prime movers, but only that part of the field in which the power units are portable. Perhaps with equal propriety its name might be Mobile Power. There is no other power magazine in this highly specialized field, but it seemed clear to the publisher that the time is ripe for the introduction of such a magazine.

The problems of the designers and users of large stationary power units have only a general kinship with the problems that exist where small, portable power units are required. To make this strikingly evident take the problem of full efficiency in a turbogenerator plant of 50,000 kilowatts running continuously, and contrast it with the fuel problem in a 5 horse-power gasoline motor used intermittently to operate a construction derrick. In the first case the full consumption per kilowatt-hour is of paramount importance. In the second case it is of negligible importance. But in the case of the small portable power unit, there looms into prominence its ruggedness and ability to stand up under rough handling and when exposed to every sort of weather. Like the modern motor on an automobile it must be "fool proof," in addition to which it must be "weather proof" and capable of working in a cloud of dust that would stifle a less rugged machine.

In a sense the portable power units that operate construction machinery are mechanical mules, and like their muscular prototypes they must be able to work in dust, rain and mud, without balking on their rough drivers. An experienced contractor knows this fact, and always has known it, and that is why it was many years before such a contractor could be induced to use a gasoline engine; for in the early stages of the development of that type of motive power units, they were as unreliable as a Hottentot's promise. The designers of those early gasoline engines were trained mechanical engineers, but their training had been in the designing of large, stationary power units, that were operated by skilled mechanics, and they had yet to learn that there is a great deal of difference between such conditions and those under which a mechanical mule must labor.

The editor recalls that a large public utility company once employed one of the most celebrated consulting power plant engineers to investigate and report on the make of automobile best adapted to their needs. The report was received and several scores of motor cars were purchased according to the recommendation of that engineer. But it soon developed that that make of car was very unsatisfactory. One of the officers of the utility company told the editor that almost the poorest car for their uses was the one that had been recommended by that celebrated power plant engineer. The reason was that although he knew a great deal about large, stationary power units, his knowledge about small, portable units that would be subjected to shocks and rough, careless usage, was really nil. In brief, there are important differences in correctly designing stationary power units and portable power units.

The designer of any machine should be very familiar with the conditions under which it is to be operated. And of course this is equally true of the buyer of the machine. The buyer often knows much more about these conditions than does the designer, so it is very important that the two shall meet to discuss their mutual problems. "Motive Power" expects to furnish a common meeting place for the exchange of facts and ideas. Here also will come the "dealer" in portable equipment operated by power, for he is not only a "middleman" in the sense that he buys to sell again, but in the sense that he conveys information from manufacturer to ultimate buyer and vice versa. He performs an important economic service in exercising both these functions. Also he should be so well informed as to the suitability of each device for any particular kind of service that he can give the best of advice to the ultimate buyer. Finally he should be able to instruct the user of the device as to its most effective handling and maintenance. Let no one think that this sort of "middleman" is an economic burden whose profits should be eliminated by eliminating his services. Quite the contrary. He performs services that can not be dispensed with without economic loss, and since the best of all ways of compensating men is to pay them in proportion to their performance, the profits made by such "middlemen" are not to be begrudged, but rather to be regarded as income earned by satisfactory service.

"Motive Power" will naturally have as its readers the designers and manufacturers of mobile power units, the manufacturers who equip their machines with such units and the dealers who sell those machines to the ultimate users. No special attempt will be made to reach many of the ultimate users with "Motive Power," although the most progressive of them will doubtless subscribe for this magazine. Other power magazines go mainly to ultimate users of power machinery. They

perform an excellent service in showing the power plant superintendent and the "engineman" how to operate machinery with economy. "Motive Power" will not duplicate that service to the ultimate user of power units, but will confine its efforts to aiding the designer and manufacturer of power units and accessory equipment, also the manufacturer who "powers" his portable machines, and the equipment dealer who distributes them to the ultimate user.

Presidents, chief engineers, purchasing agents and other officials of manufacturing companies that use powered equipment and their dealers or distributors will comprise the major part of the subscription list of "Motive Power." To give an idea of the extent of this field of mobile powered equipment the following partial list will serve:

Construction machinery:
- Concrete mixers
- Road rollers
- Road graders
- Excavators
- Derricks and hoists
- Tractors
- Trench pumps
- Air compressors
- Conveyors

Agricultural machinery
Mining machinery
Manufacturing machinery
Logging machinery
Oil field machinery
Earth borers and drillers
Portable saw rigs
Lawn and golf course equipment
Portable electric generators
Welding equipment
Spraying equipment
Fire apparatus
Pumps
Washing machines
Material handling machinery
Motor trucks

The first issue of "Motive Power" furnishes a rather extensive review of the newest developments in mobile power units and the uses to which they are put.

Mechanical Speed Regulators for Reducing Traffic Fatalities

In spite of better control of traffic at street intersections, in the city of Los Angeles the number of deaths due to traffic was 494 in 1929, as compared with 345 in 1928, an increase of 43 per cent. In Los Angeles county outside the city the corresponding deaths were 365 in 1929 and 302 in 1928, or an increase of 20 per cent. The automobile registration in that district probably did not increase more than 10 per cent in number in a year. Hence the 43 and 20 per cent increases in fatalities are staggering.

The causes of this enormous increase in traffic accidents have not been published. But the editor has motored a good deal in and about Los Angeles and he has been impressed by the great number of automobiles travelling at high rates of speed in 1929, as compared with the number of speeders seen in 1928. Also he has seldom seen any "motor cops" in Los Angeles, and "crossing cops" have almost disappeared since automatic stop and go signals were installed. Hence the inference is that motorists, in rapidly increasing numbers, have been increasing the speed of their cars and that the rapidly rising number of deaths is primarily due to increased speed of travel.

Conversation with motorists shows that few of them regard increase in speed as being a contributary cause of the increase in automobile accidents. But how many motorists know that the kinetic energy of a car increases as the square of its velocity, and that the distance in which it can be stopped by the same application of force increases correspondingly? Add 40 per cent to the speed and you double the inertia of the car. You also double the distance required to stop it. Double its speed and you quadruple its inertia and the distance required to stop the car. In the absence of knowledge of this mechanical law, few motorists would have any realization of the great increase in accidents that must occur when speeds are even moderately increased in any region where traffic is at all dense. That the density of traffic is a big factor is well shown by the fact that during a year traffic deaths increased 43 per cent in the city of Los Angeles, as compared with 20 per cent in the county of Los Angeles outside of the city.

What steps can be taken that will assuredly reduce the number of traffic fatalities attributable to speed? Restoration of "motor cop" brigades? That would undoubtedly be effective but it would also be very expensive. Just as "traffic cops" have been replaced by automatic signals at crossings, so "motor cops" should be replaced by mechanical speed regulators in cars. Such regulators are already in use on motor-trucks whose owners wish to prevent speeding. They should be attached to all motor-cars, and switched into activity whenever a motor-car enters a zone where signs indicate that a certain speed limit is to be observed. When a lever is moved, or a button is pushed, the speed regulator should be made operative, and coincidently a light or other signal should appear on the front or rear of the motor-car, indicating that the driver is obeying the speed limit sign because his car is automatically prevented from exceeding the speed limit. There could be two or more speed limits thus provided on each car.

Under such mechanical control the duties of "traffic cops" would become mainly duties of inspection of cars and a patrolling of regions within which speed limits are to be enforced. It would require few such traffic inspectors to enforce the use of the automatic speed regulators.

About 9,000 persons lost their lives in America during the past year as a result of motor vehicle accidents and twice that number were injured. Without question, a very large percentage of those deaths and accidents would not have occurred had the speed of travel been less. Even railroad crossing accidents are known frequently to be due to speeding; and such accidents could be reduced if speed regulators were switched on whenever a crossing sign indicated the necessity of reduced speed.

Attempts to educate motorists to be cautious have been made for a decade or more; yet the traffic death rate continues to increase more rapidly than the increase in motor vehicles. Such "education" having proved futile, let us adopt methods that certainly will not fail to stop a large part of the annual slaughter for which fast-driven cars are responsible.

H. P. Gillette

New Truck Mixer

A new truck mixer has been developed by Stephen Stepanian, vice-president and general manager of the Arrow Sand and Gravel Company, of Columbus, O. This machine, although primarily a truck mixer, can be used for transporting premix concrete; ready mixed mortar, and sand gravel and crushed stone, and can also mix building mortar.

The mixer consists of a drum with a short cylindrical center section and frustrum ends supported on a framework of structural steel shapes. The design of the mixer is such that no heavy cumbersome structure is required. The mixing blades are self-cleaning and give an unusually rapid and thorough mix because of the figure eight mixing motion. The drum is water, air and steam tight, the latter being an advantage when hauling hot concrete for winter construction. The water tank, which is easily connected or detached, does not add any extra height to the unit and the water is applied by gravity at both ends of the cone at a point above the mass in the mixer. This not only insures a rapid and uniform mix but a free flow of water as well. The mixer fits any standard truck, all structure of the unit being above the chassis frame, and the entire unit is attached to the chassis by four bolts.

The mixer is loaded at the top direct from the bingates through a specially designed rack and pinion gate with roller bearings. This is 12 in. wide and 34 in. long, allowing rapid loading or discharge and rendering the interior of the drum easily accessible for cleaning, inspection or repair. The open top loading eliminates any necessity of premixing of aggregates by means of special loading equipment and the drum does not revolve as the mixer is being charged.

To unload the drum it is turned until the gate is at the bottom. The material discharges onto an 8-ft. belt conveyor with a capacity of 2 cu. yd. per minute and adjustable to discharge at different heights up to 7 ft. A swing chute at the end of the conveyor allows the concrete to be deposited within a radius of 7-ft. from this point. This chute folds beneath the conveyor when not in use or when in transit.

No hydraulic hoist is required to dump the contents of the mixer and there are no extra motors. Both agitator and conveyor are driven from the truck power plant by direct, chain, multiple vee belt or gear drive as desired. The drive is mechanically simple and no special clutch is required as the gears are always in mesh. A single lever in the truck cab operates all the mechanism. When pushed one way it operates the mixer, and in the opposite position operates the belt conveyor.

The 2½ yd. size is at present the only one being made. This is mounted on a 3½ ton truck chassis and has a total loaded weight of 12 tons. A maximum of 10 hp. is required to operate the mixer and the application of power is uniform, with no high torque.

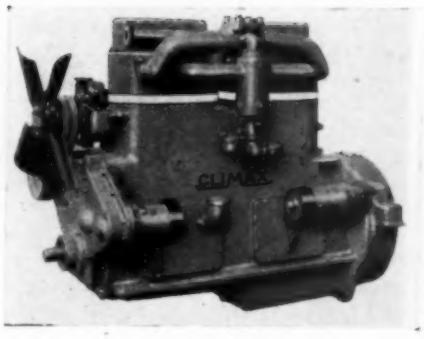
Shows Discharge Valve Opening of Mixer Open on the Side of the Drum. Also Shows the Belt Conveyor in Low Angle Position at Farthest Point from Back of the Wheels of the Truck, Which Is About 16 Ft.

Climax Adds to Blue Streak Line

As the result of years of successful production of heavy duty industrial engines, Climax Engineering Co., Clinton, Ia., has combined this experience with recent technical developments to bring out a new line of gas, gasoline and distillate burning engines that have outstanding performance characteristics.

Climax has built a combustion system into its engines that gives an unusual performance in so far as power output and economy of fuel are concerned. The new Blue Streak line possesses low detonating characteristics, so that the trend towards cheaper fuels in carbureting engines could be taken advantage of without excessive sacrifice in power and efficiency.

Climax has produced in less than a year four new engines of this new design entitled the "Blue Streak Series." All of these have specially designed combustion chambers with overhead valves, very large and efficient cooling systems, and combustion controlled to give high efficiency with corresponding increase in power output for any given displacement.



The NA-4 72 H.P., 4 Cylinder 5¼x6½ Engine

Valving, spark plug location and flame travel are controlled to secure low detonating values and unusually smooth operation with high power development.

All these engines will deliver 100 lb. or more, brake mean effective pressure at normal recommended speeds of 1,000 R.P.M. with fuel rates under .6 lb. per B.H.P. Hour on gasoline and 85 lb. B.M.E.P. on distillate with fuel rates under .7 lb. per B.H.P. hour. Excellent pulling or high torque at low speeds is also secured with this power output and compression ratios are held at relatively low values.

This new Blue Streak line is now available to the trade in the following sizes:

Model	Bore In.	Stroke In.	No. Cyl.	Distillate H.P.	Gasoline H.P.	Speed
R16	6	7	6	130	150	1,000
R14	6	7	4	85	100	1,000
NB	5¾	6½	4	72	85	1,000
NA	5¼	6½	4	61	72	1,000

Even illustrations of these new engines indicate clearly their general characteristics in appearance and design. All parts are exceedingly accessible and sturdy. Provision is provided for the usual ignition, governing and electrical equipment needed for all ordinary requirements and applications.

Thew Produces New Lorain 45

The Lorain 45, a new ¾-yd. capacity shovel, crane, clamshell and dragline, is announced by the Thew Shovel Co., Lorain, O., supplementing its present line of product, the 1-yd. Lorain 55 and the 1¼-yd. Lorain 75.

The basic design and construction principles of the Lorain 55 and Lorain 75 units are reflected in the new Lorain 45, which is built to the Thew center drive design in turntable, truck and shovel boom.

The superstructure or turntable is powered by a Waukesha type H. S. motor with 5½-in bore, 6½-in. stroke, developing 71 hp. at 1,000 rpm.

The power transmission consists of a power take and a silent chain drive carrying the power directly to the center drive pinion. This pinion meshes

New ¾-Yd. Lorain 45

directly with the three power shafts, the hoist, swing and crowd or travel shafts, and constitutes the entire power transmission of the Lorain 45. Each of these three power shafts is independently controlled through a large internal expanding band clutch. Each shaft may be separately engaged with the full power of the motor applied to it; or any combination of these shafts may be effected for simultaneous operations.

This superstructure is mounted on a 2-speed Thew center drive crawler, similar to the Lorain 75 mounting, but modified for the ¾-yd. capacity. A vertical travel shaft and a horizontal propelling shaft comprise the major crawler drive. All the propelling gears, steering clutches, etc., run in a constant oil bath in a heavy steel crankcase placed up high to afford generous ground clearances. The steering clutches of the crawler are mounted on splined shaft sections, a new innovation.

Crawler high travel speed is 1½ mph., climbing a 15 per cent grade; low speed is ¾ mph., climbing a 30 per cent grade. Both speeds are available for travel in either direction with equal efficiency, regardless of the length of travel. A full range of boom equipment for shovel, crane, clamshell and dragline units is furnished for the Lorain 45.

The shovel boom is an all-steel, full box-section boom. This dipper stick is an all-steel welded rectangular section with a patented "far-reach" greenhorn at one end.

The dipper on the Lorain 45 is tripped by an automatic power dipper trip. This is located on the turntable and consists of a small clutch device on the end of the swing shaft. A small lever, to the operator's immediate right, when engaged by a slight pressure, actuates this device, causing a pull on the trip rope which automatically trips the dipper once and then returns to "ready" position.

The crane, clamshell and dragline booms are all-steel, latticed booms, built in two sections, with interchangeable boom heads. The standard boom is 35 ft. long, although various lengths of boom head sections and middle sections can be furnished for longer booms.

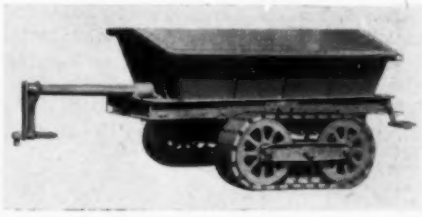
A fully descriptive bulletin on the ¾-yd. Lorain 45 may be had by addressing the Thew Shovel Co., Lorain, O.

Davenport "Cat-Tread" Dump Wagons

The Davenport Locomotive & Mfg. Corporation, Davenport, Ia., manufacturers of the Davenport line of industrial locomotives for the past 30 years, has announced recently production of a new line of crawler type dump wagons. These are to be marketed under the name of "Davenport Cat-Tread Wagons."

These wagons are designed for use with tractors of the crawler type. It is claimed the large supporting area of the "Cat-Treads" combined with the use of Timken bearings in the wheels, make it possible to haul full loads with minimum tractive effort under the most adverse conditions.

Davenport Cat-Tread Wagons at the present time are made in two sizes—of 5 and 7 cu. yd. capacity. The 5 yd. wagon weighs 8,400 lb. and the 7 yd. wagon approximately 10,500 lb. Capacity of both wagons are based on level measure and these capacities are increased from 1 to 2 cu. yd. by the application of an auxiliary side board



New Davenport 5-Yd. Wagon

which may be readily fitted to the low side of the dump body.

Cat-Tread wagons at the present time are made only with bottom dump. A simple, efficient and easily operated dumping and wind-up device is located at the rear. The dump doors drop vertically, permitting free discharge of the load and non-interference with the dumped material. It is contemplated by the Denevonport Locomotive & Mfg. Corporation to later add further models to include a 3-way dump body for use on jobs where it is necessary to dump over the edge of a fill or where other conditions may make it desirable for other than bottom dump.

Among the special features claimed for Davenport Cat-Tread wagons, the following construction features seem most important: the Cat-Tread assembly is very rugged in all details and is rated at 15 tons capacity; the tread assembly is of special analysis steel specified because of its tough, wear resisting quality; the one piece wheels which carry the treads are assembled in a rugged "H" frame which it is claimed keeps the wheels in constant alignment and prevents broken or twisted axles when operating over uneven ground.

The main frame is a 9 in. ship channel, which provides maximum rigidity of the dump body. The axle hanger is an alloy steel casting riveted to the frame channel. To prevent bulging, a tie rod extends across the frame and is secured to the axle hangers. It is claimed that the design of the axle hangers and the materials used insure long life in service and prevent failures due to torque set-up when turning, or to twisting.

New Air Compressor

A new model air cooled single stage compressor has just been placed on the market by the Gardner-Denver Co., of Quincy, Ill. This is to be known as the A-C-E model. It consists of a 3½ by 4 duplex compressor and a 5 hp. motor mounted on a cast iron base on top of the air receivers. The unit has a displacement of 26 cu. ft. per minute, operating at a rate of 600 revolutions per minute. This rate can be reduced and altered to fit the particular circumstances.

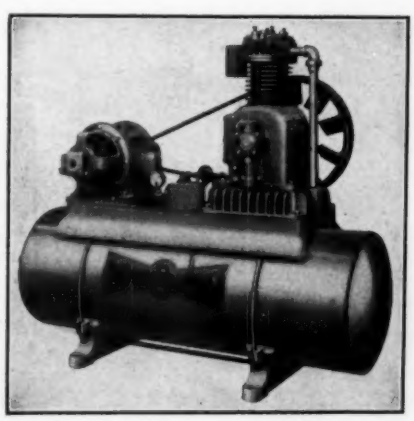
An outstanding feature is the enclosing of the suction and discharge valves in separate compartments. The valves are special, heat treated and ground steel discs. The use of the compartments prevents the air from being heated when passing through the intake valves.

An automatic or hand operated start and stop control is furnished as standard equipment and operated in conjunction with the Penn type pressure and moisture unloader. The unloader is set to cut in at 130 lb. and out at 165 lb. Continuous operation is assured by this control.

Lubrication for the compressor is by the controlled splash type. A positive driven plunger pump on the outside of the crank-case feeds filtered oil to the troughs under the connecting rods. A special oil ring and groove on the piston prevents oil from passing over to the discharge lines. An oil level gives positive indication of the amount of oil in the reservoir.

Other features of this compressor are:

The use of the V-type belt drive; a fan type of flywheel; use of Hyatt type of roller bearings; aftercooler in the base and a muffler for the suction opening.



New A-C-E Model Single Stage Compressor

Joslin Produces Weather-proof Sign

Two sizes of four-way street signs are produced by A. D. Joslin Manufacturing Co. of Manistee, Mich., in all types of assemblies, irregular or standard. They have a 2½-in. letter; the large size has a 3½-in. letter. Highly

White Way Street Sign, New York Type

polished embossed aluminum letters assure maximum readability from any angle and at all hours of the day or night.

The background of black Du Pont Duco makes this an unusually legible combination.

No bolts or screws are used, the entire assembly being locked by one nut at the lower threaded end of the center post.

Other types of Joslin street sign assemblies are available, including four-way box type; four-way right angle; two-way right angle; two-way single unit; and others. Various types of brackets for mounting on light and telegraph poles, etc., are also furnished.

For further information apply to A. D. Joslin Manufacturing Co., 38 S. Dearborn St., Chicago.

Surface Mixer for Bituminous Concrete

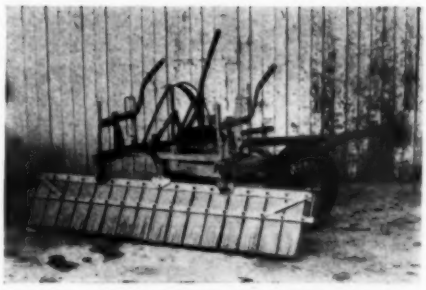
A surface mixer for bituminous construction has been placed on the market by Sam Finley, Inc., Atlanta, Ga. The operation, in brief, is as follows: The machine moves over a roadway and while in motion picks up surface aggregates, mixes it with bitumen and then returns the mixture to the road. The illustration shows the machine in operation. The primary blades rotate and tumble the aggregate through a spray of bitumen, and the secondary blades repeat the process in the reverse direction. The rear blade levels the mixture, leaving a layer of bituminous concrete. The process allows scientific grading of aggregrates to secure the most effective use of liquid bitumen, and cut-back materials.

The machine will operate successfully on surfaces composed of top-soil, sand-clay, chert, gravel, macadam or other water-bound types, with the addition of new aggregate to supplement the deficiencies or the thickness of the old material. After this addition the machine mixes the new and old to homogeniety before spraying, and thus produces a fully coated layer of well graded bituminous concrete.

Rear View of Surface Mixer on 9 Ft. Strip

A Broom Road Maintainer

A gravel road maintaining machine developed in the state of Washington is illustrated. This machine is known as the Owen Road Broom. Its heart is the broom, 1,024 spring-steel wire bristles, sharp enough to agitate the crust, comb and carry surface material a long way before letting it out, filling the low spots, cutting the high ones. The road broom weighs 1,200 lb. Its entire weight can be applied to the road through the bristles by simply shifting the levers. Its ability to cut the surface crust is varied by changing the angle of the broom to the road—the straighter the broom, the more it cuts. By a simple adjustment, it distributes its material to either right or left. It can be pulled behind power grader, any light tractor or 1-ton truck. The broom itself is reversible.



The Owen Road Broom

The Jerry Caldwell Co., 1040 6th Ave., South, Seattle, Wash., are the national distributors for this machine.

Correction: Robertson Guard Fence

An error which appeared in the January issue of Roads and Streets is corrected as follows:

The W. F. Robertson Steel and Iron Company manufactures the woven wire road guard shown in the cut on page 37 labeled "Cyclone Guard Fence on the Job" instead of the Cyclone Fence Company. The W. F. Robertson Steel and Iron Company are designers and manufacturers of this style of guard which weaves perfectly into the old style guard for repair purposes and the weight per 100 lineal feet is approximately the same.

Robertson Chain Link Road Guard

The latest product is their three-inch by number four gauge copper bearing metal, hot dipped, galvanized woven wire chain link road guard, used for highway protection. The guard was developed to replace the old style two-inch mesh by number six gauge guard. It is over two and a half times as strong as the old style guard, but at the same time is flexible and resilient, offering cushioning effect against blow by automobile.

The Jay Walker Wins.—The jay walker appears to have won his fight against regulations preventing him from blithely ignoring all traffic rules, according to the Erskine Bureau for Street Traffic Research. During 1929 none of the larger cities succeeded in establishing effective pedestrian control systems.

Roads enough, *soon* enough, *safe* enough

QUANTITY production yielded cars enough to clog our roads. Now it will take quantity production—and equally effective economy—to provide roads enough, soon enough, safe enough to relieve the existing conditions.

Every community which approaches this problem with due attention to obtaining maximum mileage, speedy completion and safety, will be irresistibly attracted by Tarvia performance and Tarvia economy.

For 26 years, Tarvia low-cost construction and low-cost maintenance have been applied with memorable success to all types of highways. Tarvia today meets these requirements more impressively than ever — for it will take the utmost economy to provide, even from the stupendous sums available, roads enough, soon enough, safe enough.

The Barrett Company

New York	Chicago	Philadelphia
St. Louis	Minneapolis	Boston
Detroit	Cleveland	Birmingham
Buffalo	Columbus	Milwaukee
Providence	Syracuse	Cincinnati
Baltimore	Toledo	Rochester
Lebanon	Youngstown	Bethlehem

In Canada:
THE BARRETT COMPANY, Ltd.
Montreal, Toronto, Winnipeg, Vancouver

Tarvia
GOOD ROADS at LOW COST

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Trackson Company Stepping Out

In keeping with their recently adopted expansion program, which provides for the development of a complete line of Trackson tractor equipment, officials of the Trackson Company, Milwaukee, Wis., have announced plans for the erection of a new factory early in the spring. According to W. H. Stiemke, vice-president, and L. E. Dauer, sales manager, the company has obtained a very desirable site of 21 acres in Milwaukee's south side manufacturing district.

The new plant will be a large, one-store building, up-to-the-minute in plan and construction and equipped to provide every facility for most efficient, modern production. It is planned, moreover, to make it not only a model manufacturing plant, but an attractive, imposing building as well, that will be an addition to Milwaukee's industrial section. Among other things, the plans call for the landscaping of the property as soon as the building is completed.

L. E. DAUER
Sales Manager
Trackson Company
Milwaukee, Wis.

The entire Trackson plant will be housed in the new factory, which will provide ample room for the manufacture of the complete line of tractor equipment which the company is developing. Also, the move will consolidate under one roof the several plants which the Trackson Company now operates in Milwaukee.

Although the Trackson Company is only seven years old, its business has grown remarkably in that time. It was organized in 1923 as a division of the Geo. H. Smith Steel Casting Co., Milwaukee, and originally manufactured only full-crawlers for Fordson tractors.

W. H. STIEMKE
Vice-president & Gen. Manager
Trackson Company
Milwaukee, Wis.

About a year and a half ago, the company officials adopted a diversification program, and since then have added a number of new lines. At present they manufacture Trackson full-crawlers, shovels, loaders, bulldozers, cranes, hoists, hitches, etc., for McCormick-Deering industrial tractors, as well as for Fordsons, and it is expected that their expansion program will lead to the development of a complete line of equipment for other well-known makes of tractors.

Trackson tractor equipment is sold through dealers and distributors and is used throughout the world for road construction and maintenance, contracting, public works, snow removal, winter and summer logging, oil field work and many other industrial operations. The intensive development of export markets has contributed in no small way to the Trackson Company's success and today tractors equipped with Trackson full-crawlers and other Trackson equipment are found all over the world doing every kind of work, from towing boats along the dikes of Holland, to transporting men and munitions for the Japanese Army, building oyster beds in the flats of the Pacific Coast, conquering the bush of Australia, and hauling logs in the great forests of Northern Canada.

The special, electric alloy steel castings which are used in the construction of Trackson tractor equipment are made in the company's own foundry. Thus every Trackson crawler, loader, shovel, etc., is produced almost entirely in the Trackson plant, from raw materials to assembled machines, giving the manufacturers a complete check on the quality of their products.

The addition of the other lines which the Trackson Company plans to manufacture when they are established in their new factory will place them among the world's largest manufacturing organizations of complete lines of tractor equipment.

Hubbard-Floyd to Represent Foote Company, Inc.

Announcement has been made by the Foote Company, Inc., of Nunda, New York, of the appointment of The Hubbard-Floyd Company, Inc. as their representative for the territory in Connecticut, New York and New Jersey, adjacent to New York City.

The Hubbard-Floyd Company will represent The Foote Company in the same territory as that formerly handled by Frank E. Hall, whose recent death and the closing of his estate makes the change necessary.

The Hubbard-Floyd Company, whose New York headquarters are located at 167th Street and Sedgwick Avenue, have a large, modern warehouse and shop in connection with their offices at the above address, and employ a large force of competent mechanics. It is stated that they will carry a stock of parts on hand for MultiFoote pavers.

Gardner-Denver Announces Personnel Changes

T. H. Driscoll, formerly of the Chicago office of the Gardner-Denver Company, has been transferred to the Los Angeles branch. Fred V. Moore, who has been covering the eastern states, has been transferred to Phoenix, Arizona.

Rock drill products will be handled from the New York office by R. J. Featherstone, and the London office will be represented by Ian Duncan. Mr. Duncan has come from Edinburgh, Scotland to take preliminary training in the American plants of the Gardner-Denver Company, and on his return will represent the entire line of this company's products.

Chain Belt Company sales for 1929 are announced as just over eight million dollars. This is nine hundred thousand dollars more than in 1928, according to C. F. Messinger, General Sales Manager. It is expected that the Chain Belt Company's earnings for 1929 will be $7.00 per share. For 1928, they were $5.27, and the average for five years is $5.10.

2 complete CENTRAL MIXING PLANTS like this for

Each of the two Blaw-Knox Central Mixing Plants which Wiley-Maxon Construction Company are using on the Columbia-Wrightsville Bridge consist of the following equipment--

A 500 barrel Cement Bin, equipped with a screw conveyor arrangement to transfer the cement to the Batchers on the 100-ton Blaw-Knox Batcherplant. This Batcherplant is equipped with a Volume Batcher and a Blaw-Knox Inundator. A Ransome Mixer is the mixing unit on each plant.

Two thoroughly reliable Blaw-Knox Central Mixing Plants—one at each end of the job—feature the concreting operations on Wiley-Maxon Construction Company's tremendous bridge project over the Susquehanna River.

Contractors have learned to rely upon the ability and experience of Blaw-Knox to furnish efficient plants for central mixing. Blaw-Knox Central Mixing Plant installations have made it possible to produce specification concrete on thousands of jobs, large and small.

Permit Blaw-Knox to make recommendations for your Central Mixing Plants. You will be placed under no obligation if you avail yourself to this engineering service.

BLAW-KNOX COMPANY
2003 Farmers Bank Bldg., Pittsburgh, Pa.

New York Cleveland Philadelphia Chicago
Detroit Birmingham Boston Buffalo Baltimore

Export Division:
Milliken Bros.—Blaw Knox Corp., Canadian Pacific Bldg., New York

BLAW-KNOX

TRADE MARK BLAW-KNOX REG. U.S. PAT. OFFICE

Sweet's Steel Company Increases Plant Capacity 80 Per Cent

Sweet's Steel Company, one of the pioneers in the rerolling industry, has introduced so many improvements in the mills and equipment during the past eight months, that the increase of the capacity of the plant amounts to approximately 80 per cent.

The changes made have involved the installation of new mills, new furnaces, motor drives, annealing beds and other necessary equipment. The products manufactured by this company now number well beyond 100, and include light steel rails and accessories, such as plain splice and angle bars, steel mine ties, frogs, switches and other items for industrial track haulage systems; steel fence, sign and route marker posts of the flanged leg channel type, concrete reinforcing bars and other special shapes.

Steel posts represent a comparatively recent departure in the company's activities, but even more recent is the manufacture of concrete reinforcing bars. Before entering this field of activity much research work was done, looking toward an improvement of all products.

It is said, that by the new and improved process bars with a much higher degree of ductility are produced by means of a special annealing system. Exhaustive tests have been made as the development has been watched with interest by engineers in building construction.

Sweet's Steel Company was founded in Syracuse, New York, by William Sweet in 1868. From a single idea and a small beginning there has developed in this particular diversification of the steel industry 20 or more plants, involving an investment totaling approximately $70,000,000.

In 1903, when a growing business called for a location for the plant where it would be possible to secure its raw material supply more advantageously, lower fuel costs, make shorter hauls and lower freight rates on the products, it was decided to accept the invitation of the Williamsport Board of Trade to locate in Williamsport. It was at this time that Mr. Sweet desired to retire and disposed of the company and assets to a group of men who had been associated with him over a long period of years.

The plant of the company occupies approximately 50 acres and has, in addition thereto, approximately 42 acres occupied by 96 company houses for its workmen. From an employment point of view the company is considered a valuable asset to the city of Williamsport; and furnishes on incoming shipments of raw material and out going shipments of finished products a very heavy tonnage for railroad haulage. Branch offices and sales agencies are maintained in all the important cities in the United States and abroad.

The control and management of the company is in charge of men all residents of Williamsport. Joseph J. Kaye is chairman of the board of directors and Daniel F. Swartz, president. Other officers are: William P. Beeber, vice-president; Charles C. Steel, vice-president in charge of sales and sales engineering; John E. Spotts, treasurer; Clarence L. Peaslee, secretary; John A. Schultz, general superintendent.

Young Radiator Secures Services of G. H. Palm

George H. Palm, for the past six years engineer with the new development division of the Yellow Coach and Manufacturing Company, Pontiac, Michigan, a division of General Motors, has become connected with the Young Radiator Company, manufacturers of truck, bus, power unit and engine cooling radiators, as well as heating units. This company is located at Racine, Wisconsin, where Mr. Palm will have charge of radiator construction and equipment.

Mr. Palm has long been connected with the engineering and development of motor coach, bus chassis and its excessories. His experience in this line furnishes a splendid background for his new work which has to do with the development of various types of radiators and equipment for heavy duty service. Mr. Palm has been a member of the Society of Automotive Engineers since 1919.

Sterling Motor Truck Corp. to Establish Factory Branch in Maine

The Sterling Motor Truck Corporation of Boston has signed a lease with the Casco Merchantile Trust Company to establish a branch in the building at 185 Washington Avenue, Portland, Maine, formerly occupied by the Portland Auto Sales Company and before that used as an electric car station for the Portland and Yarmouth Street Railway Co. The branch is to be under the management of Hugh J. McKinnon, formerly Portland branch manager for the Mack Motor Truck Company and well known in his line in this section of New England.

In an interview with Mr. McKinnon it was learned that the new factory branch opened for business about the latter part of January and has a complete line of Sterling trucks on display. "In fact," said Mr. McKinnon, "there will be the largest assortment of trucks on our display floor in the state of Maine. The great size of the building allows us to give an exceptionally large space to display.

"The parts department will be large and a big supply of truck parts will be carried at all times. The sevice department will be open for work on all makes of trucks at all times, being the only one of its kind in this section to operate on 24 hours per day schedule."

Dewey Robinson, who was with Mr. McKinnon at the Mack Truck branch for many years, will have full charge of the service department. The branch will employ 12 people and will have for its territory Maine, New Hampshire, Vermont, Maritime Provinces, City of Montreal and a part of Quebec.

Introducing Mr. D. E. Boisemenue

Mr. D. E. Boisemenue, whose picture appears with this item, has just been made assistant manager of the asphalt department of the Standard Oil Company of Indiana.

D. E. Boisemenue, Assistant Manager, Asphalt Department, Standard Oil Company of Indiana

Mr. Boismenue has been interested in the asphalt business since 1905, having started in East St. Louis in that year in laboratory work. Subsequently he was head of manufacturing departments of various roofing manufacturing companies. In 1916 he joined the Standard Oil Company, leaving two years later, to return again in 1921. Before his recent appointment he was the company's expert on roofing and specialty asphalts.

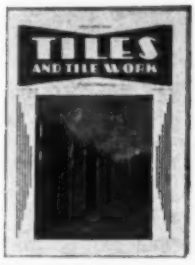
George T. Honstain

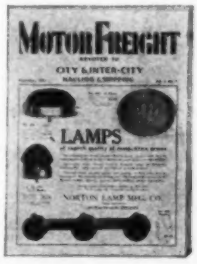
Friends and business associates of George T. Honstain will be sorry to learn of his death, which occurred on Thursday, January 16th, in Minneapolis.

Mr. Honstain was chairman of the Board of The Western Crucible Steel Casting Company.

GILLETTE PUBLICATION
GPC
EST. 1906

EACH A LEADER IN ITS FIELD!





ATTENTION
INTEREST
DESIRE
ACTION

The old formula still works, and your advertising story is half way over when you choose as your National Medium a Gillette Publication.

Attention and Interest are assured because both have been secured by presenting your message to the readers of magazines of highly specialized types appealing directly to their fields of work.

You profit by the experience of a quarter of a century and all it means in service and prestige by selecting a Gillette publication which gives coverage of the field without waste circulation.

The three engineering papers, known as The Gillette Construction Group, are supplemented by Data Reference and Buyers' Guide Catalogs.

The factors making up the Gillette publications include: Editorial acceptance; aggressive policies; technical knowledge; field achievements; latest developments; essential details; attractive presentation and—*service always.*

Each publication is an independent unit, backed by the entire Gillette organization. Men experienced in the fields covered give assurance to readers and advertisers of authoritative leadership and dependable service.

Specialization of editorial content for the reader, means selective circulation coverage for the advertiser.

A Direct Mail Service to back up your national advertising includes 110,000 classified names, guaranteed 98% accurate.

Write for full information, circulation statements and rate cards.

GILLETTE PUBLISHING COMPANY

223 East 20th St., Chicago

SAN FRANCISCO
LOS ANGELES
CLEVELAND
NEW YORK

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Manufacturers' representatives located in New York would like to add line of heavy contractors' equipment of established reputation, other than the lines now handled by them. They would like exclusive sales rights for such equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Representatives Wanted

Manufacturer of truck, adapted to many uses, has attractive territory open in Missouri, Kentucky, Kansas, Nebraska and several southern states.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Manufacturer of excavating equipment desires to build up distribution organization throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

Manufacturer of automatic dipper trip, adapted to any type shovel (steam, gasoline, diesel, electric, etc.); with rapidly growing business, is seeking additional representatives.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Manufacturer of rotary pump, especially designed for road construction work, has proposition for reliable distribution houses.

Good side-line offered to manufacturers' representatives covering municipalities and public institutions.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of air compressors and contractors tools has number of desirable territories open. Full co-operation will be extended to distributors.

Ask the Operator

IF you ask any experienced shovel or crane operator to name the easiest operating machine he ever handled, the chances are that he will name the Half Yard Insley—if he has ever been on one.

The reason is that the Insley has direct connected cone clutches that are powerful and positive and yet which have a fine degree of engagement that gives the operator absolute feel of the load . . . . That is why the Insley has always been so easy to operate . . . . That is why it has always been able to operate at speeds that would be hazardous for machines with other types of clutches.

And that is one reason why the Insley has that extra degree of performance that makes a profit—and one reason why Insleys have been the choice of men who understand and appreciate good excavating machinery.

743

INSLEY

INSLEY NEC

INSLEY MANUFACTURING COMPANY Engineers and Manufacturers INDIANAPOLIS, INDIANA *Division of National Equipment Corporation*

Four Big Buda Diesels Take a Western Trip

The accompanying picture shows four model D4-30 Buda M. A. N. Diesel engines as they looked before leaving the factory of the Buda Company at Harvey, Ill., to become the property of the New Mexico Construction Company, Albuquerque, N. M., representing a $30,000 shipment. These units develop a maximum of 120 b.h.p. and operate at a speed of 800 r.p.m. to 100 r.p.m. They are to be used for operating Cedar Rapids No. 2 crushers in connection with highway construction.

The skids upon which the engines are mounted makes for minimum effort in moving from one job to another. Each engine is enclosed with sheet metal housing, which may be padlocked at night to eliminate danger of tampering.

They've Gone to New Mexico to Help Build Good Roads

The conventional automotive type of radiator is made in sections, so that in case of damage, section may be removed and repaired without interrupting the operation of the engine, except for the brief time required for the removal and replacement of the section.

Many desirable features are embraced in the units, including outboard bearing and paper belt pulley, and disc type clutch enclosed in conventional type bell housing. The net weight of the units is approximately 9,000 lb.

Other sizes of these engines, used for many different classes of service are built by The Buda Company.

Barrett-Cravens Purchased by Walker Vehicle Company

Walker Vehicle Company (which is an Insull Company, being a subsidiary of Commonwealth Edison Company) has purchased the capital stock of Barrett-Cravens Company, manufacturers of lift-trucks, lift-truck platforms, portable elevators and structural steel storage racks. This will prove of interest to the materials handling equipment field in the linking together in ownership and management the Barrett-Cravens Company with Walker Vehicle Company, Chicago, and Automatic Transportation Company, Inc., Buffalo.

The Automatic Company is the pioneer manufacturer of electric industrial trucks and tractors, while Walker Vehicle Company is one of the oldest motor truck manufacturers, having been in business since 1903, manufacturing a full line of electric trucks for street use.

It is expected that the pooling of experience and talent developed by these three companies will assist in the development of the electric and hand lift-truck field.

Nashville Tractor & Equipment Company Show Rapid Growth

Although the Nashville Tractor & Equipment Company has been in business only one year, they report that due to the large volume of business shown on the books for 1929, their capital stock has been increased from $25,000 to $75,000.

This company handle a complete line of road machinery, including brands of the following equipment:

"Caterpillar" tractor and road machinery; Euclid Wagons and graders; Killefer road rippers and scrapers; Wiard plows and scrapers; General wheelbarrows; Empire blades; Willamette-Ersted hoists; Domestic pumps; Haiss loaders, conveyors and buckets; Gardner-Denver air compressors and tools; P & H shovels and cranes; Speeder shovels and cranes; LaPlante-Choate wagons and bulldozers; Atlas scrapers; Union explosives and Toledo torches.

Highway Shoulder Machine Company Reorganizes

Announcement has been made to the effect that Moritz-Bennett Corporation has been organized as successors to the Highway Shoulder Machine Company of Effingham, Illinois.

It is stated that the ownership and personnel of the new organization remains practically the same as formerly. Officers are announced as follows: E. A. Moritz, president; M. M. Bennett, vice-president in charge of sales; C. M. Mount, vice-president and treasurer; Sarah Stern, secretary; J. S. Raleigh, manager of production and service, and B. C. Conner, plant superintendent.

Charles M. Nuckolls Joins H. D. Conkey & Company

According to announcement Charles M. Nuckolls, formerly with the International Harvester Company, Chicago, has accepted a position with H. D. Conkey & Company of Mendota, Illinois.

Prior to his connection with the International Harvester Company, Mr. Nuckolls was associated with the Whiting Corporation, Harvey, Illinois, and the Shaw Crane Works, Muskegon, Michigan.

House Magazines*

Editor's Note: This column is published every now and then. Many most attractive and interesting house magazines come to our desk from time to time, and we take this method of acknowledging them.

Sauerman News.—The January issue of this little magazine is No. 1 of Volume 8 and is published by Sauerman Bros., Inc., of Chicago. It is printed on such good paper stock and the illustrations are so profuse and clear-cut that it attracts the reader's interest at once. This number contains articles on Making Highway Cuts and Fills with 1-yd. Portable Scraper; Sluicing Streams Carry Away Material Dug by Scrapers; Two Slackline Cableways Help Build Diablo Dam, and many other equally interesting topics.

Dependable Highways. The January issue of this paper, which is published by the National Paving Brick Manufacturers Association of Washington, D. C., contains as its leading article a paper presented by P. M. Tebbs, assistant chief engineer Pennsylvania Department of Highways on "A Brick Pavement on the William Penn highway." There are several graphic illustrations.

The Monarch Operator, the official organ of the Monarch Operators' Club, the purpose of it being to arouse enthusiasm and maintain contacts between Monarch tractor operators throughout the world. Members of the club, who must be Monarch operators vouched for by dealers and distributors, and holding membership cards, are contributing writers for the magazine, furnishing stories and pictures of actual experiences in the field. A prize picture contest is now underway for the best pictures of Monarch tractors in action. All Monarch tractor operators the world over are invited to join this club. Information may be secured from dealers or by writing the Tractor Division of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

*Manufacturers named will be pleased to send above mentioned publications to readers upon request.

Nations Are Neighbors

Man's craving for flexible and mobile means of movement has been met and in the giant system of steamships and airplanes, railroads and motor vehicles which we have seen created in the last century, a new field of opportunity has been developed beyond even the imagination of those who have gone before us. Distance has been obliterated by the magic touch of the Aladdins of transportation and nations have become neighbors in a degree which would have been impossible to residents in adjoining towns 100 years ago. *From The Road Builders' News.*

Here is a

MOORE SPEEDSHOVEL

owned by Thomas B. Madden Construction Co., Chicago, digging to seventeen foot depth and loading truck with ease. (It can dig to twenty feet). This Speedshovel "Made in Manitowoc" not only has power to do the toughest kind of digging but to climb out of deep excavations. When crawling out the crawler lock absolutely prevents shovel from running down incline. The independent chain shovel crowd maintains uniform grades and accelerator motor control gives variable speeds and power. Steering is done independently from the cab.

Write for our new catalog—it gives many more advanced engineering and exclusive features found only in the Moore, "Made in Manitowoc."

MANITOWOC ENGINEERING WORKS, *Manitowoc, Wis.*

(Sole Licensee to manufacture and sell Moore Speedcranes and Shovels)

MOORE • MANITOWOC

SPEEDCRANE

SHOVEL ~ CRANE ~ TRENCHOE ~ DRAGLINE

Universal Atlas Cement Co. New Title of United States Steel Subsidiary

Announcement has been made of the sale of the Atlas Portland Cement Company to the United States Steel Company, of which the Universal Portland Cement is a subsidiary, and the business of both companies will now be conducted under the name of the Universal Atlas Cement Company. The companies included under this name are the Atlas Portland Cement, the Universal Portland Cement, the Atlas White Portland Cement and the Atlas Lumnite Cement.

The Atlas and Universal companies have grown up with the cement industry, and each is a third of a century old. The same general policies under which they have operated will continue, it is said. Improved service to customers is expected as a result of the combined productive capacity and sales territory acquired by the new arrangement. Relationships between buyer and seller remain unchanged, as the new company assumes all obligations of the Atlas and Universal companies.

Plants of Universal Atlas Cement Company are located at Hudson, New York; Hampton, Pa.; Universal, Pa.; Buffington, Indiana; Duluth, Minnesota; Hannibal, Missouri; Independence, Kansas; Leeds, Alabama, and Waco, Texas. Offices are maintained in all the principal cities.

O. A. Stellar Made Ad Manager for McEverlast, Inc.

Announcement has been made by McEverlast, Inc., to the effect that Mr. O. A. Steller, formerly editor of "Concrete" magazine, has been appointed as advertising manager for their organization.

It is stated that the rapid growth of the McEverlast activities in all sections of the United States and foreign countries has made it necessary to enlarge the general staff and to center activities having to do with the distribution of information regarding the McEverlast products in the newly created publicity department. Mr. Steller's background of engineering, technical advertising and editorial experience starts him in his duties well equipped.

Previous to his connection with "Concrete," Mr. Steller was employed by the Portland Cement Association in the Chicago headquarters. He served this organization in both the road bureau and in the advertising and publications bureau. During the more than ten years with these two organizations, Mr. Steller has traveled extensively, visiting engineering projects and consulting with engineers in every section of the country. He has contributed engineering articles to a great many engineering magazines and has been active in engineering society attendance. He is now 39 years old.

Mr. Steller received his technical education at Marquette University and the University of Wisconsin, and secured his first practical experience in mining projects for the Peabody Coal Company, the engineering staffs of the Wisconsin Highway Commission, the Chicago, Milwaukee, St. Paul & Puget Sound Railway, the Chicago, North Shore & Milwaukee Electric Railway, and the U. S. Geological Survey.

In announcing the appointment of Mr. Steller, the McEverlast Company believe that they have strengthened the staff of their organization, which means another step forward in keeping with their progressive policies.

H. O. Penn Machinery Adds Warco Line

The Warco graders, manufactured by W. A. Riddell of Bucyrus, Ohio, are to be represented in the New York territory by H. O. Penn Machinery Company, Inc., located at Port Morris Terminal, 140th Street and East River, New York City.

In taking on the Warco graders, which are equipped with McCormick Deering tractors and for which the Penn Company also have the agency, the distributors believe the new arrangement will prove most successful. The grader can also be equipped as a snow plow.

Another line recently taken on by the distributing company is the Ames six cylinder gasoline road roller, driven by a 60 H. P. Hercules 6 cylinder motor. The Penn Company report that since the addition of this line a very satisfactory volume of business has been secured and they are predicting a great future for it in their territory.

H. O. Penn, Pres. Penn Machinery Co., New York

E. N. Millan, Recently Appointed Chief Engineer, American Rolling Mill Co., Middletown, O.

National Equipment Becomes Operating Organization

Announcement has been made that on Jan. 1, 1930, the National Equipment Corporation became an operating company. This organization is a consolidation of the Koehring and T. L. Smith Companies of Milwaukee, the Insley Manufacturing Company of Indianapolis, The Parsons Company of Newton, Ia., and the Kwik-Mix Concrete Mixer Company of Port Washington, Wis.

Headquarters of the corporation are located at 31st St. and Concordia Ave., Milwaukee. Mr. Philip A. Koehring is president and general manager.

Mr. R. E. Brooks, for a number of years engaged in the equipment business in New York, was recently elected vice-president and will be in charge of sales.

The officers of the National Equipment Corporation are: P. A. Koehring, president and treasurer; W. H. Insley, vice-president; H. E. Smith, vice-president; H. C. McCardell, vice-president; W. J. Koehring, vice-president; R. E. Brook, vice-president; W. J. Zimmers, secretary; G. E. Long, comptroller; and C. A. Koehring, assistant treasurer.

Wanted Sales Engineer

A contractors' equipment sales engineer to travel throughout the United States, under 40 years of age and, if possible, with an acquaintance among distributors, is being sought by manufacturer. Adequate salary and expenses plus commission is offered. Send your application to Distributor News, stating age, education, experience and past earnings. Same will be forwarded to manufacturer and will be held confidential.

Cut Your Costs and Lower Your Bids

With Thor SIX AIR COMPRESSORS

Here's a message of vital importance to you. You CAN cut your operating costs with Thor 6 Super-Charged air power. You CAN reduce delays and upkeep costs. You CAN cut days off the contract time.

WHY? Because the Thor 6 Air Compressor is equipped with a Super-Charger which enables it to actually deliver more air than any other Compressor of the same rating or capacity.

The Super-Charger of the Thor 6 is not just "sales talk". It means more air for your money. It means that you can buy the Thor Compressor rated at 250 cu. ft. instead of a 310 cu. ft. machine and operate just as many tools; or you can buy the Thor Compressor rated at 116 cu. ft. instead of a 160 cu. ft. size and accomplish the same results. And this means quite a saving of money to you which is an important consideration.

Furthermore the Thor 6 eliminates bulkiness and trouble because it is a single direct-connected unit. It has no clutches, couplings or gears. A deep section type cast steel frame makes a rigid foundation for the unit, minimizing vibration and distortion.

Weigh all of these things in your mind and compare them with other compressors and you will realize why the Thor is the best compressor buy on the market.

On the basis of more air for your money, the Thor deserves an investigation. Make us prove the things we say. The obligation is on our part, not yours, and the saving in money involved is well worth the time spent. Complete information is yours for the asking.

SEND FOR THIS FREE BOOKLET

Which illustrates and describes the Patented Super-Charger and construction features of Thor Compressors. A brief, interesting story. Write for this booklet now. No obligation—no red tape. Merely send in the coupon below.

INDEPENDENT PNEUMATIC TOOL CO.

256 So. Jefferson Street
CHICAGO, ILL.

Independent Pneumatic Tool Co.:
Send me Free Booklet on THOR COMPRESSORS.

Name.....

Firm.....

Address.....

Town.....State.....

ROADS AND STREETS

H. P. Gillette Editor

Vol. LXX MARCH, 1930 No. 3

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